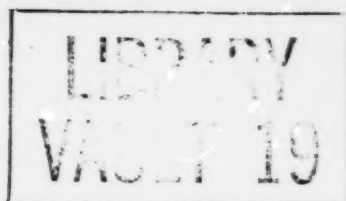


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PHASE I PALEONTOLOGICAL ASSESSMENT FOR
THE OLDMAN RIVER DAM ENVIRONMENTAL
MITIGATION/OPPORTUNITIES PLAN.

PREPARED FOR:
ALBERTA ENVIRONMENT
PLANNING DIVISION

APRIL 1985



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BRIAN JONES, Ph.D., P. Geol.

487-1883

EXECUTIVE SUMMARY

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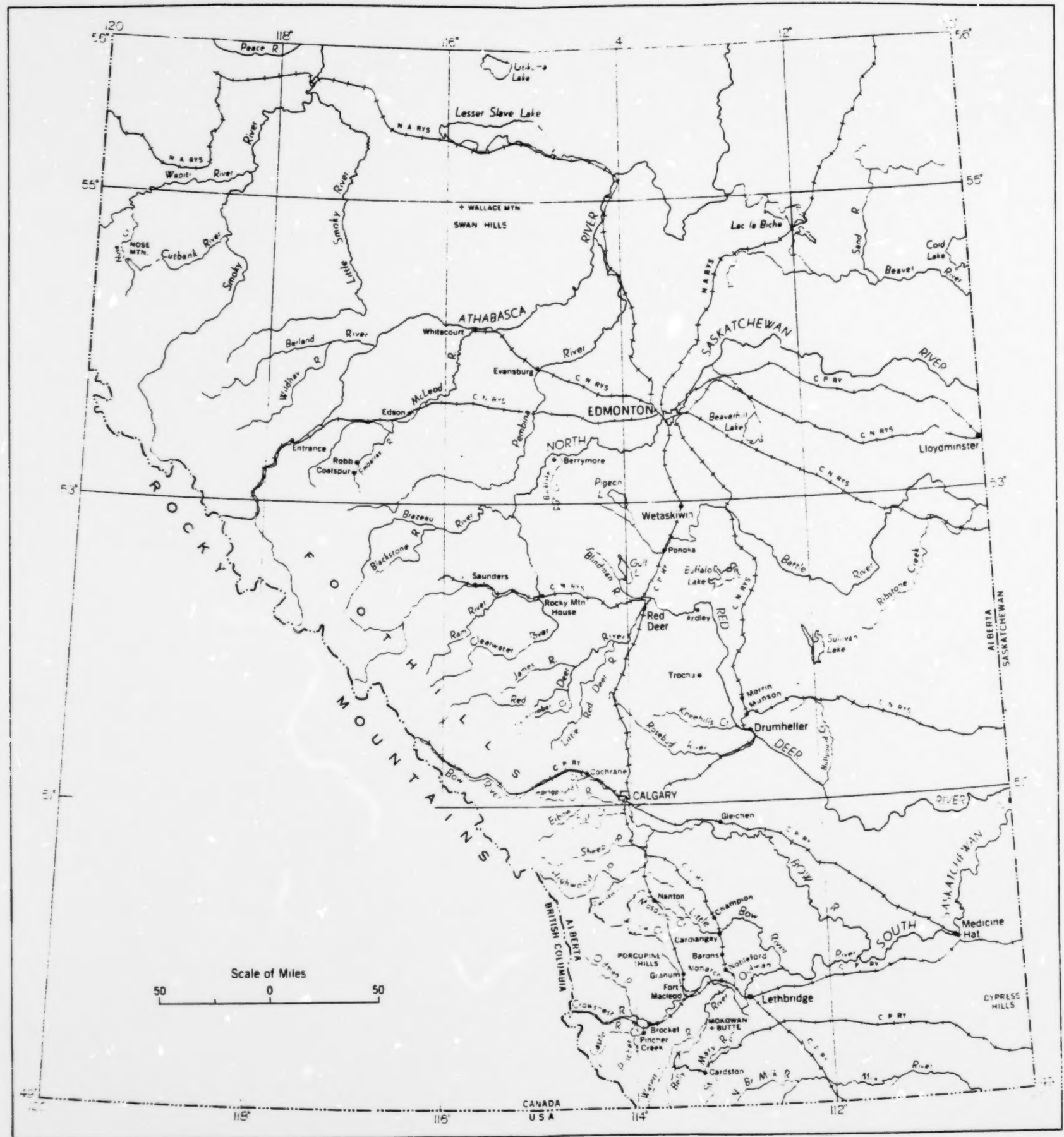
The study area embraces those parts of the valleys of the Crowsnest, Oldman and Castle rivers that will be flooded once the dam has been built. The Upper Cretaceous - Tertiary succession of the study area encompasses the Belly River, Bearpaw, St. Mary River, Willow Creek and Porcupine Hills formations. Analysis of the available literature suggests that while these formations have been studied in some detail to the north, east, south and west of the study area, little has actually been done in the study area itself.

The Bearpaw, St. Mary River and Willow Creek formations are known to contain good invertebrate and vertebrate fossils. A diverse flora is also known from some of the strata. The status of the Belly River Formation, which potentially has importance from the point of view of vertebrate fossils, is essentially unknown. The available evidence suggests that the study area may certainly contain very important paleontological material.

It is readily apparent that intensive fieldwork is required in order to (1) verify the geological map - especially with respect to the status of the Belly River Formation in the vicinity of Lundbreck, (2) obtain detailed information on the lithological characteristics of all the formations in the study area, (3) compile a detailed interpretation of all the depositional environments represented by the strata in the study area and (4) provide a full, detailed assessment of the paleontological potential of the area. Such detailed assessments are not possible from the available literature.

Analysis of air photographs of the study area shows that there are 74 exposures in the area that should be investigated. Some of these exposures, however, are in vertical or near vertical cliffs and may not be accessible. The easiest way of reaching the exposures will be from the rivers themselves using boats.

INTRODUCTION



INTRODUCTION

This study encompasses three main components, namely:

- (1) An assessment of the paleontological material collected or known from the strata that crop out in the areas along the Crowsnest, Castle and Oldman Rivers which will be flooded once the dam is constructed across the Oldman River (Fig. 1).
- (2) An assessment of the paleontological material collected or known from strata which crop out in the area immediately around the area that will be flooded once the dam has been built. Such strata may or may not be directly affected by the dam. Nevertheless, such an assessment should give a good indication of material that may be present in the strata of the area that is going to be flooded.
- (3) The strata that crop out in the river valleys that are to be flooded are parts of formations that underlie vast tracts of land in Alberta as well as Montana. Study of such strata, as well as that of different formations that are of the same age, should provide good indications of the paleontological material that might be found if a detailed collecting program was implemented for the area that is to be flooded once the dam is built.

From the assessments detailed above it should be possible to determine the present state of our knowledge regarding the paleontological resources of the area that is to be flooded. This study is based solely on a literature search and information obtained from individuals who have worked in the area. As such it can only highlight the known information and assess the potential of the area from a paleontological point of view. Nevertheless, it should be feasible to determine if a comprehensive fieldwork program is required for the detailed assessment of the area. If such is the case, then this study will pinpoint the areas which have the highest potential of yielding important paleontological material.

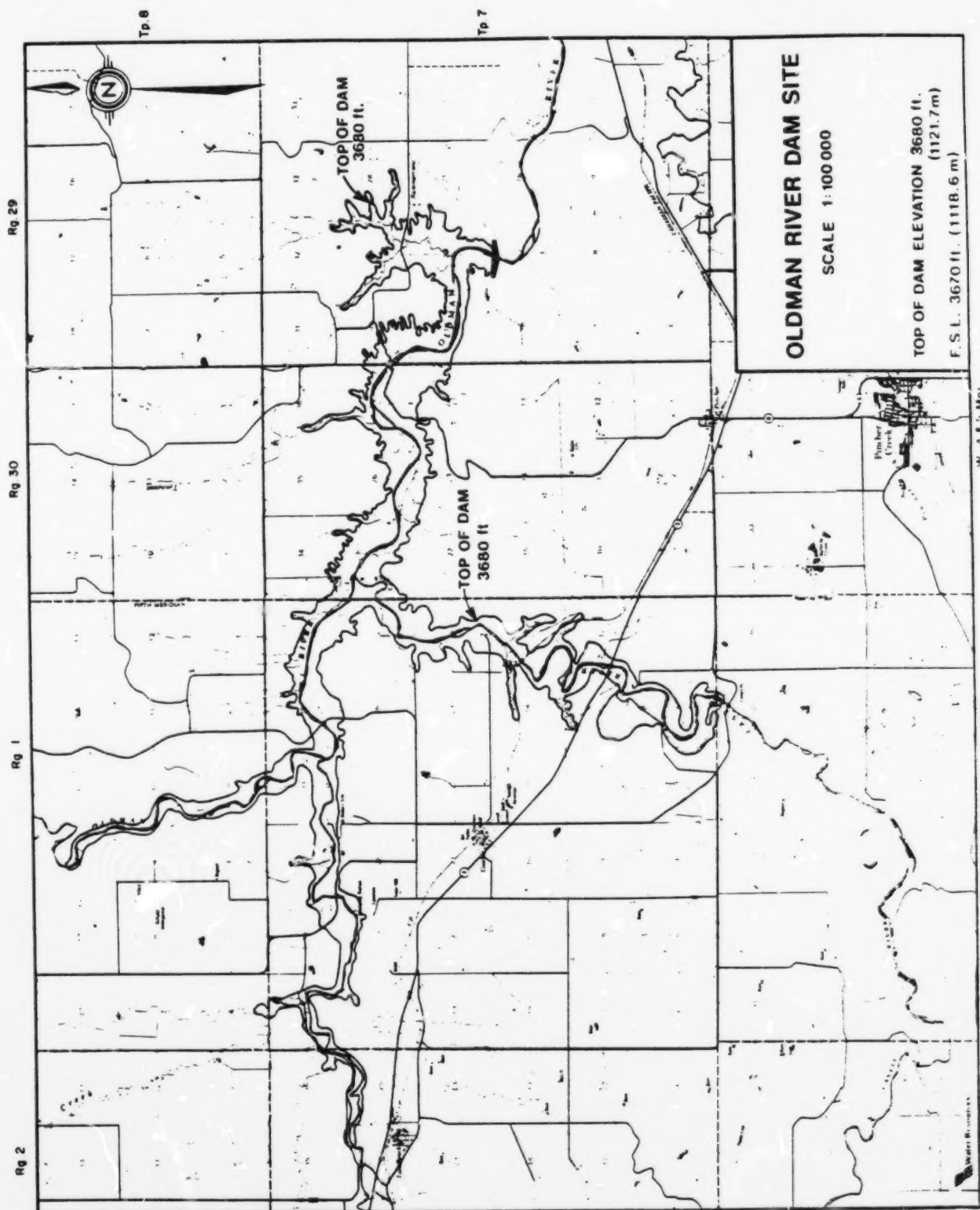
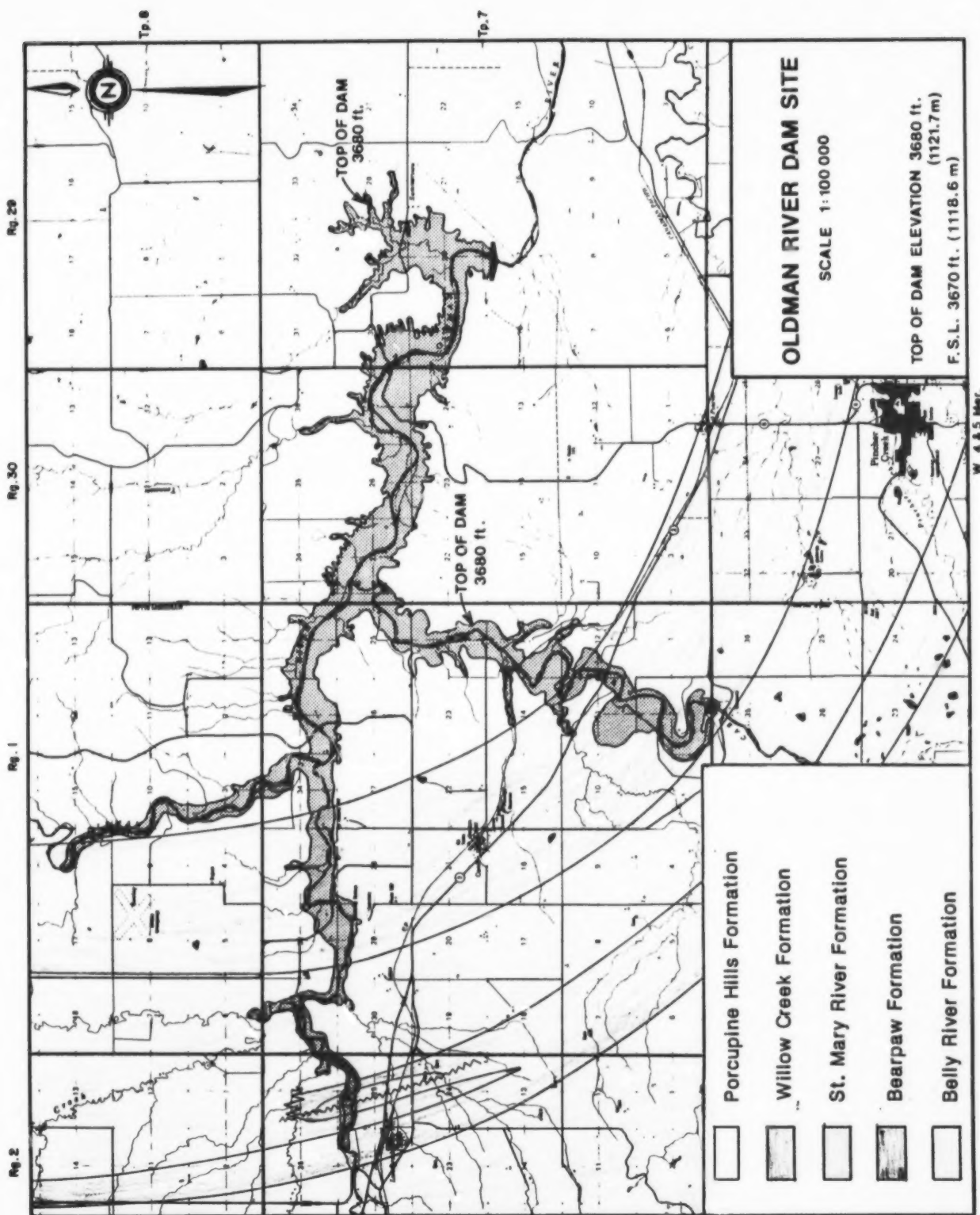


Figure 1:-- Map of study area showing areas to be flooded once the dam has been built.

STRATIGRAPHIC SUCCESSION

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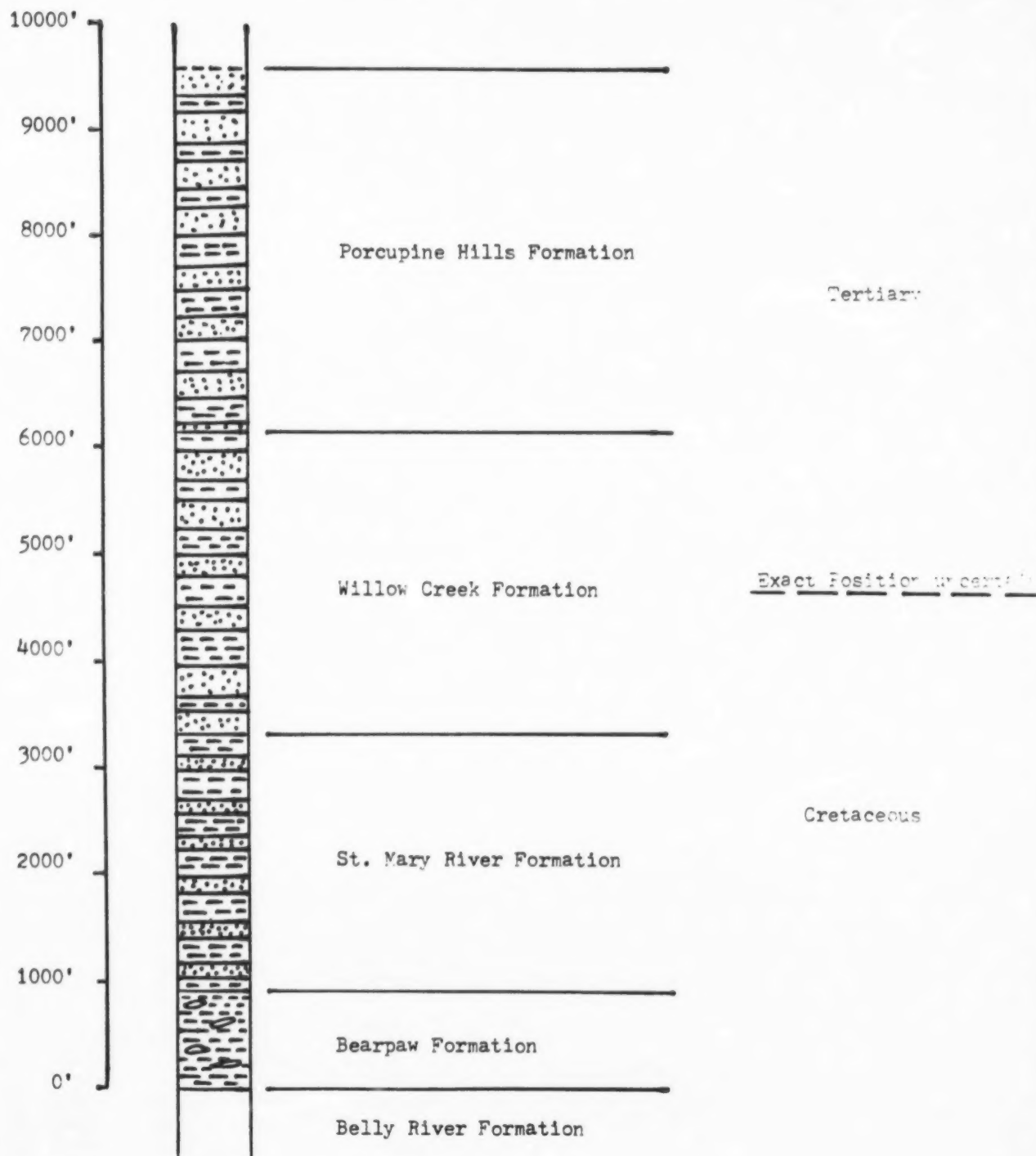
STRUCTURAL SETTING

The strata exposed along Crowsnest River, Oldman River and Castle River are part of the eastern limb of the Alberta Syncline. The northwest - southeast trending fold axis of the syncline lies to the east of the study area. In the western part of the study area (i.e. in the vicinity of Lundbreck) the structure is more complicated because the strata form the eastern part of the Disturbed Belt (Fig. 2). The dip of the strata is highly variable in a west to east direction along the Crowsnest River, but in general there is a decrease in dip towards the fold axis (Fig. 3).

STRATIGRAPHIC SUCCESSION OF STUDY AREA

The strata exposed along the Crowsnest River, Castle river and Oldman River which will be affected by the flooding once the dam is built are of Cretaceous and Tertiary age. The sequence includes the Bearpaw Formation, the St. Mary River Formation, the Willow Creek Formation and the Porcupine Hills Formation (Figs. 4 & 5). Hage (1943) mapped a thin slice of the Belly River Formation on the Crowsnest River in the vicinity of Lundbreck (Figs. 2 & 3). The nature of the Belly River Formation in this thin slice is not known since it has not been specifically dealt with in the literature.

Figure 5. - Summary stratigraphic section showing succession of formations present in the study area. To the east of the study area, the Kneehills Tuff occurs at the top of the St. Mary River Formation. Sequence based on data from Hage (1943).



BELLY RIVER FORMATION

Original description:

Type section:

Lithology: In the Crowsnest River area to the west of that affected by the flooding, the Belly River Formation encompasses approximately 2,600 ft (800 m) of alternating sandstone and shale units (Hage - descriptive notes with GSC map 816A). Hage divided the succession into five assemblages,

- 1) 0 to 153 ft (0-47 m). Transitional from underlying Wapiabi Formation, comprising dark grey shale alternating with beds of fine to medium grained, brown sandstone.
- 2) 153-708 ft. (47-218 m). Coarse, light grey, crossbedded sandstone and minor interbedded shale.
- 3) 708-1808 ft. (218-556m). Almost equal sandstone and shale. The sandstone is fine to medium grained, grey and brown weathering, 40 to 50 ft (12-15 m) thick units at base and 10 to 20 ft (3.1-6.2 m) at top. The shales are grey.
- 4) 1808-2108 ft. (556-648 m). Concretionary layers separated by sandstone beds that are up to 20 ft. (6.2 m) thick. One sandstone unit near the base contains brown weathering concretions while another sandstone unit, near the top, contains calcareous concretions.
- 5) 2108-2608 ft. (648-802 m). Alternating beds of sandstone and light grey, bentonitic shale. Several coal seams occur near the top of the formation in the vicinity of Lundbreck.

Depositional environment: Hage, in the descriptive notes associated with GSC map 816A, suggested a freshwater origin for the rocks of the Belly River Formation of the area.

BEARPAW FORMATION

Original description: Stanton and Hatcher (1905, p. 13).

Type section: Northern Montana.

Lithology: Stanton and Hatcher (1905) named the formation for a sequence of "...dark clay shales with many calcareous concretions immediately overlying the Judith River beds."

In southwest Alberta the Bearpaw Formation has been briefly described by many different authors. Stewart (1919) described the formation as a succession of dark clay shales with some quite large calcareous concretions that commonly contained fossils. The large disk-shaped concretions, in particular, commonly have a large ammonite as their nucleus. Williams and Dyer (1930) amplified the description of the formation by noting that it comprised dark grey, greenish grey and chocolate brown, soft, fissile shales with local beds of soft sand. Williams and Dyer (1930) also drew attention to the elliptical concretions that commonly have fractures filled with calcite. They noted concretions up to 5ft (1.5m) that commonly contained fossils while the surrounding shales contained no fossils. Locally, calcareous beds with Pteria, Placenticerias and Baculites also occur. Russell (1932a) described a similar sequence and in addition, noted the occurrence of bentonite beds in some areas. Russell and Landes (1940) also noted the occurrence of impure sandstone beds near the base of the formation in some areas.

In the study area Hage (descriptive notes on GSC map 816A) described the formation as a sequence of shale with some reddish brown concretions that are up to 18 ins (0.46 m) in diameter. He noted that the sequence was well exposed along the Crowsnest River. In 1943, Hage described the Bearpaw Formation that outcrops along the Crowsnest River in sections 25 and 26, tp. 7, rge. 2. The sequence he described is essentially the same as that described by previous workers on the formation. He did note, however, that a section on the north bank of the Oldman River in section 11, tp. 10, rge. 2 included 12 ft (3.7 m) of fine grained sandstone.

Bell (1949), Russell (1950), Douglas (1951) and Price (1963) also alluded to the Bearpaw Formation but added no new information to that already known.

Boundary with the Belly River Formation: On the Oldman River in sec. 11, tp. 10, rg2. 2 the contact between the Belly River Formation and the Bearpaw Formation is exposed in the north bank. Hage (1943, p. 7) noted that the top of the Belly River Formation is marked by a 6 in (15 cm) thick coal bed. This coal bed, however, is not present everywhere. Thus, for the Callum Creek map area, situated north of the Cowley map area, Shaw and Douglas (descriptive notes with GSC map 982A) placed the boundary at the point where the silty green and grey shales of the Belly River Formation gave way to the rubbly grey shale of the Bearpaw Formation. They also noted that thin beds of coal and carbonaceous shale occur in the upper part of the Belly River Formation.

Depositional Environment: The presence of ammonites in the concretions in the Bearpaw Formation indicate that the original sediments of this formation accumulated in a marine setting.

ST. MARY RIVER FORMATION

Original description: Dawson (1883, p. 5).

Type section: St. Mary River

Lithology: Stewart (1919) noted that an estimated 2,700 ft (830 m) of the St. Mary River Formation was well exposed along Crowsnest River and that almost complete sections occurred on Castle River and Pincher Creek. Stewart (1919) described the formation as a series of highly calcareous, light grey sandstones with minor amounts of sandy shales. He noted that the lower part of the formation is more shaley and calcareous than the upper part. Coal seams and oyster beds are common throughout the formation (Stewart, 1919). The sandstones are fine grained and locally contain small pieces of coal and shale. On the Crowsnest River, Stewart (1919) noted the occurrence of thin coal seams at two horizons in the formation that is exposed downstream of Lundbreck.

Williams and Dyer (1930) suggested that the formation was very similar to the Belly River Formation, especially with respect to the sandstones. These authors showed that the sandstones of the St. Mary River Formation consisted of very fine to fine, subangular grains of quartz, feldspar, biotite, muscovite, chlorite, apatite, zircon and tourmaline. The calcite cement of the sandstone varied from 10 to 60% (average 10%) of the rock.

Russell (1932a) described the formation from southeastern Alberta as a series of alternating sandstone and shale units. He noted that the calcareous sandstones are grey to buff, commonly hard and massive. Seams of coal and carbonaceous shale are common in the basal part of the formation. Russell and Landes (1940) studied the St. Mary River Formation from the area to the east of the dam site and noted that the sandstone units were commonly lenticular. The formation, as might be expected, is well exposed along St. Mary River.

Hage in the descriptive notes associated with GSC map 739A (1940) estimated the formation to be 2,500 ft. (769 m) thick on Castle River. He described a 4 ft. (1.2 m) thick oyster bed lying above a 2 ft. (0.6 m) thick coal seam near the base of the formation. Hage also documented the occurrence of numerous, thin coal seams and beds of

St. Mary River Formation (continued)

carbonaceous shale throughout the formation.

In his more detailed appraisal of the Cowley map area, Hage (1943) suggested that the formation could be divided into two parts; the dividing line being drawn at a coal bed that is overlain by a thick oyster bed. Although this coal seam - oyster bed couplet appears to be the same as that described in the notes accompanying GSC map 739A, the stratigraphic position does not match exactly. On GSC map the couplet is placed near the base of the formation; however, Hage (1943) used the couplet to divide the formation into two parts and the descriptive notes with GSC map 816A state that the coal seam - oyster bed couplet is 118 ft. (36.3 m) above the base of the formation.

The lower part of the formation, as defined by Hage (1943), comprises dark grey shale alternating with hard, grey, brown weathering sandstone in beds several feet thick. Hage (1943) noted that the lower part of the formation is well exposed along Crowsnest River. The upper part of the formation comprises hard, grey, brown weathering sandstone beds interbedded with light and dark grey shale and carbonaceous beds. Coal beds occur near the bottom of the upper part of the formation. The sandstone, which is in beds 5 to 25 ft. (1.5-7.5 m) thick, is fine to medium grained, highly calcareous and usually crossbedded.

On Castle River, the oyster bed at the base of the upper part of the formation is 4 to 6 ft. (1.2-1.8 m) thick and the underlying coal 29 inches (0.7 m). Overlying the oyster bed is 100 ft (30.7 m) of massive, medium to coarse grained, grey, brown weathering sandstone that contains ferruginous concretions and pelecypods. Above this, there are poorly exposed, dark grey shale and carbonaceous shale with coal seams and fine grained sandstone.

To the north of the Cowley area, in the Callum Creek map area, the formation consists of crossbedded, fine to coarse grained, grey to buff weathering, hard and soft, grey sandstone interbedded with silty shale, grey and green shale, carbonaceous shale and calcareous ironstone concretions (descriptive notes with GSC map 982A). Along the Oldman River there is at least 3,000 ft. (923 m) of the formation incompletely exposed.

St. Mary River Formation (continued)

To the south of the study area, in the Pincher Creek area, Douglas (1951) identified three divisions of the St. Mary River Formation. The lower part, which is 200 to 250 ft. (61 to 77 m) thick, comprises dark grey and green shales, coal seams, oyster beds and other shell coquinas. The sandstones in this part of the formation are typically reddish brown. The middle part, 1300 ft. (400 m) thick on Pincher Creek, consists of green and grey, silty shales with very lenticular, soft, grey, massive, coarsely cross-bedded sandstones. The upper part of the formation, 630 ft. (194 m) thick on Pincher Creek and 180 ft. (55 m) thick on Waterton River, comprises laterally continuous, hard, thin bedded sandstones. Tozer (1956) noted that it was not easy to divide the formation. There is, however, a continuous zone of thick-bedded sandstone which Douglas (1950, p. 50) and Tozer referred to as the "Blocky Sandstone". This sandstone unit, which is 109 ft. (33.5 m) thick on the Oldman River, is present in many sections and can be traced into a similar sandstone member, in a similar stratigraphic position, which occurs in the Highwood River section of the Edmonton Formation.

Bell (1949) and Tozer (1956) both noted that the St. Mary River Formation thickens to the west. Thus, on St. Mary River it is 1,160 ft (357 m) thick, on Oldman River approximately 1,500 ft. (461 m) thick (Russell, 1932a) while on the eastern edge of the disturbed belt it is 2,500 ft. (769 m) thick.

The St. Mary River Formation is a widespread stratigraphic unit which can be traced from Glacier County, Montana (Stebinger, 1916, p. 127) to township 14 in Alberta. To the north the formation passes laterally into the Edmonton Formation.

Price (1962) briefly described the St. Mary River Formation but added no new information to that already known.

Boundary with Bearpaw Formation: Not specified in publications dealing with the study area.

Depositional environment: Although there are indications that some parts of the formation may have originated in brackish water conditions (Hage, 1943) most of the formation originated as freshwater sediments (Douglas, 1951; Russell, 1950).

WILLOW CREEK FORMATION

Original description: Dawson (1883, p. 3).

Type section: Willow Creek

Lithology: Stewart (1919) described the formation as a series of clays, shales, soft sandstones and a little thin-bedded limestone. The formation has a pronounced red color along with various shades of purple, maroon and brown. Stewart (1919) noted that the sandstones are usually fine-grained, calcareous and thin-bedded. Stewart (1919) also noted that the formation is well exposed on the Oldman River west of the Porcupine Hills.

Hage (1943) described the formation, which outcrops in the Cowley map area, as a series of interbedded light to dark grey, maroon, reddish brown shales and light grey, fine grained, soft calcareous sandstones. The basal part of the formation contains more shale than sandstone; however, the proportion of sandstone increases higher in the formation (Hage, 1943). In the Cowley map area, outcrops of the formation are almost totally confined to the banks of the principal river valleys of the area, namely Castle River, Crowsnest River and Oldman River. Almost the entire formation is exposed along Castle River.

The descriptive notes associated with GSC map 20-1967 indicate that the Willow Creek Formation is well exposed along the Oldman River, St. Mary River and Waterton River to the east of the study area. The succession in this area is essentially the same as that in the Cowley map area, although the shale units are described as containing numerous small, irregularly shaped calcareous concretions.

In the Callum Creek map area, to the north of the Cowley map area, Douglas (1950) divided the formation into five members which he designated A, B, C, D and E.

Member A. interbedded grey sandstone and grey, green and purplish shales, some of which contain abundant concretions.

Member B. similar to member A but red shale also present.

Member C. coarse to conglomeratic sandstones

Member D. soft grey sandstone and varicolored shales with concretions.

Member E. thick to massive, buff weathering sandstone interbedded with 'normal' Willow Creek Formation rocks.

Willow Creek Formation (continued)

Tozer (1956, Fig. 2) summarized the information concerning the internal divisions of the formation in different sections (Fig. 6).

Williams and Dyer (1930), Russell (1932a), Russell and Landes (1940), Bell (1949), Douglas (1951) and Price (1962) also described the Willow Creek Formation with respect to their own studies but essentially added no new information to that already known.

Boundary with the St. Mary River Formation: The Willow Creek Formation lies conformably over the St. Mary River Formation and differs mainly with respect to its distinctive reddish color and to some extent by its weathering character ("badland"). The precise position of the lower boundary has not been specified in the literature dealing with the study area. To the west of the study area, on the western limb of the Alberta Syncline, the boundary is placed at the Kneehills Tuff.

Depositional environment: Douglas (1951) suggested that all the sediments of the Willow Creek Formation are non-marine.

PORCUPINE HILLS FORMATION

Original description: Dawson (1883)

Type section: Porcupine Hills

Lithology: Stewart (1919) described the formation as a series of fine grained, calcareous sandstones with lesser amounts of interbedded greyish, shaley clays. Williams and Dyer (1930, p. 62) noted that the sandstones in the Porcupine Hills Formation were strongly cross-bedded, fine-grained sandstones. They also noted the occurrence of a 5 ft. (1.5 m) thick pebble bed at the base of a thick sandstone unit which outcrops on the east bank of the Oldman River just above its junction with the Crowsnest River. Some of the sandstone units contain ripple marks and desiccation cracks.

In the Cowley map area, Hage (1943) described the formation as a series of interbedded sandstones and shales with the proportion of sandstone increasing up section. The fine to coarse grained, calcareous grey sandstone occurs in beds 20 to 50 ft. (6.1-15.4 m) thick that commonly form distinct, large outcrops on the hillsides.

The Porcupine Hills Formation was also briefly described by Russell (1932a), Bell (1949), Douglas (1951), Price (1962) and in the descriptive notes associated with GSC maps 20-1967 and 982A.

Boundary with Willow Creek Formation: Russell (1932a) noted that the boundary between the Porcupine Hills Formation and the Willow Creek Formation is usually indefinite. The lower 150 ft. (46 m) of the Porcupine Hills Formation is usually softer and more argillaceous than is typical for the formation. Bell (1949) argued that the Porcupine Hills Formation can be differentiated from the underlying Willow Creek Formation by the dominance of thick sandstone beds which are generally more strongly crossbedded and harder than those of the Willow Creek Formation.

Depositional environment: Russell (1932a), Hage (1943) and the descriptive notes associated with GSC map all suggest that the Porcupine Hills Formation comprises sediments that accumulated in freshwater environments.

KNEEHILLS TUFF

The Kneehills Tuff is an important marker horizon that has been recognized in the strata on the eastern limb of the Alberta Syncline. Tozer (1956) compared the tuff from this area with the Kneehills Tuff which Allan and Sanderson (1945) described from the Edmonton Formation of the Red Deer Valley and found them almost identical in all respects. In the descriptive notes associated with GSC map 20-1967, the Kneehills Tuff is recorded from the Oldman Valley. This part of the sequence comprises about 8 ft. (2.5 m) of white weathering, greenish grey, argillaceous sandstone which is overlain by about 12 ft. (3.7 m) of mauve-grey weathering, purplish black, bentonitic silty shale. The shale unit includes, near the top, a light grey weathering, brownish grey, silicified tuff bed. These units are considered equivalent to the Whitemud Formation, the Battle Formation and the Kneehills Tuff.

On the eastern limb of the Alberta Syncline the Kneehills Tuff denotes the top of the St. Mary River Formation. However, the Kneehills Tuff has apparently not been recognized on the western limb of the syncline in the Cowley map area.

AGE OF SUCCESSION

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AGE OF SUCCESSION

The succession which occurs on the western limb of the Alberta Syncline encompasses Upper Cretaceous and Tertiary strata. The position of the Cretaceous-Tertiary boundary has been the subject of some debate, mainly because the critical parts of the succession have not yielded very many fossils. Stewart (1919, p. 23) was aware of the problem and showed the Belly River to Porcupine Hills formations spanning the boundary. Williams and Dyer (1930, p. 11) were a little more certain and placed the St. Mary River Formation in the Cretaceous and suggested that the Cretaceous-Tertiary boundary occurred somewhere in the Willow Creek Formation. Russell (1932a) also agreed that the St. Mary River Formation was entirely of Cretaceous age and tentatively placed the Cretaceous-Tertiary boundary at the top of the St. Mary River Formation. Russell and Landes (1940) and Hage (1943) also placed the Cretaceous-Tertiary boundary at the contact between the St. Mary River Formation and the Willow Creek Formation. Rutherford (1947), however, took a completely different view and placed the Willow Creek Formation entirely in the Cretaceous. Bell (1949) argued against such a view and suggested, on the basis of the flora in the formations, that the Cretaceous-Tertiary boundary lay somewhere in the Willow Creek Formation.

Tozer (1956) studied the problem in some detail, paying special attention to the successions exposed on the western limb of the Alberta Syncline. His critical section, located on the left side of the Oldman River near the center of sec. 25, tp. 10, rge. 25, W. 4th mer., is summarized below:

Unit 13. Clay, dark grey	5.0 ft
Unit 12. Shale, green, silty, very soft	8.0 ft
Unit 11. Sandstone, green, fine-grained, soft.	16.0 ft
Unit 10. Shale, light brown, silty, friable	1.0 ft
Unit 9. Shale, green, friable	1.0 ft
Unit 8. Clay, dark grey	0.5 ft
Unit 7. Tuff, light grey, very fine grained, porous	0-0.5 ft
Unit 6. Shale, dark grey, bentonitic	12.0 ft
Unit 5. Sandstone, light grey, fine grained, white	11.0 ft
Unit 4. Shale, mottle grey-green, soft	7.0 ft
Unit 3. Sandstone, grey, fine grained	4.5 ft
Unit 2. Shale, grey, friable	1.5 ft
Unit 1. Sandstone, grey, fine grained, hard	5.6 ft

Age of succession (continued)

Unit 1 of this section equated with the uppermost bed of the St. Mary River Formation as defined by Russell (1932b, p. 139). Of particular interest were units 5 to 7 which resemble, respectively, the "white sandstone", the "mauve shale" and the Kneehills Tuff of Allan and Sanderson (1945). The Kneehills Tuff is particularly significant because it is a widespread marker horizon which is usually used to divide the Edmonton Formation into lower and upper parts. Since the Edmonton Formation is entirely of Cretaceous age it means that at least the lower part of the Willow Creek Formation is of Cretaceous age.

On the western limb of the Alberta Syncline the Kneehills Tuff is absent or not exposed. Tozer (1956), however, investigated the succession exposed along the Crowsnest River and found a "definite dinosaur bone" 1,000 ft (307.5 m) above the base of the Willow Creek Formation on the left side of the river in 1.s. 8, sec. 32, tp. 7, rge. 1, W. 5th mer. This confirmed a Cretaceous age for at least part of the Willow Creek Formation.

Russell (1965) followed Tozer's argument and placed the Cretaceous-Tertiary boundary in the Willow Creek Formation, suggesting that it lay within or at the base of Member D as defined by Douglas (1951). Russell noted that the mollusc faunas in the lower part of the Willow Creek Formation were akin to the mollusc faunas in the St. Mary River Formation whereas the mollusc fauna in the upper part of the Willow Creek Formation were more similar to those from the Paskapoo Formation which is of Tertiary age.

STRATIGRAPHIC RELATIONSHIPS

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STRATIGRAPHIC RELATIONSHIPS

The succession exposed in the area that will be flooded once the dam is built comprises, in ascending order, the Bearpaw Formation, the St. Mary River Formation, the Willow Creek Formation and the Porcupine Hills Formation (Figs. 4 & 5). Some of the formations, for example, the Bearpaw and St. Mary River formations, can be traced southwards and eastwards for some distance. For example, the Bearpaw Formation can be traced into Montana (Fig. 7) as well as into the plains of Alberta (Fig. 7). To the north, however, the formations pass laterally into other equivalent formations. The stratigraphic setting and geographical extent of the formations is important since such relationships may provide indications of which fossils might be found in the strata of the study area.

The Bearpaw Formation underlies vast tracts of land in southern Alberta and Montana and appears to be relatively uniform throughout its geographic extent. To the north of the Crowsnest River area, the Bearpaw Formation grades laterally into the basal units of the Edmonton Formation (Tozer, 1956, Fig. 2).

In Montana, the Bearpaw Formation is overlain by the Horsethief Sandstone (Stebinger, 1914, p. 62). The Horsethief Sandstone is equivalent to the Blood Reserve Formation (Fig. 7) which Russell (1932a) mapped as far north as township 10 on the east side of the Alberta Syncline. The Blood Reserve Formation was originally named by Russell (1932a, p. 32) for a sandstone that had been called the "Fox Hills". Russell (1932), however, demonstrated that the Blood Reserve Formation was older than the typical "Fox Hills" and thus separated the two. The Blood Reserve Formation has been mapped by Williams (1949) and Douglas (1951) in the Cardstone and Pincher Creek map areas to the west and within the Disturbed Belt. However, the formation has not been recognized north of Castle River in the Cowley map area.

The St. Mary River Formation stretches from Glacier County, Montana (Stebinger, 1916, p. 127) to township 14 in Alberta (Tozer, 1956). To the north it passes laterally into the Edmonton Formation (Fig. 8). In the southern plains the upper part of the formation contains units that are equivalent to the Whitemud Formation, the Battle Formation and the Kneehills Tuff (Fig. 8). The correlation of the St. Mary River Formation

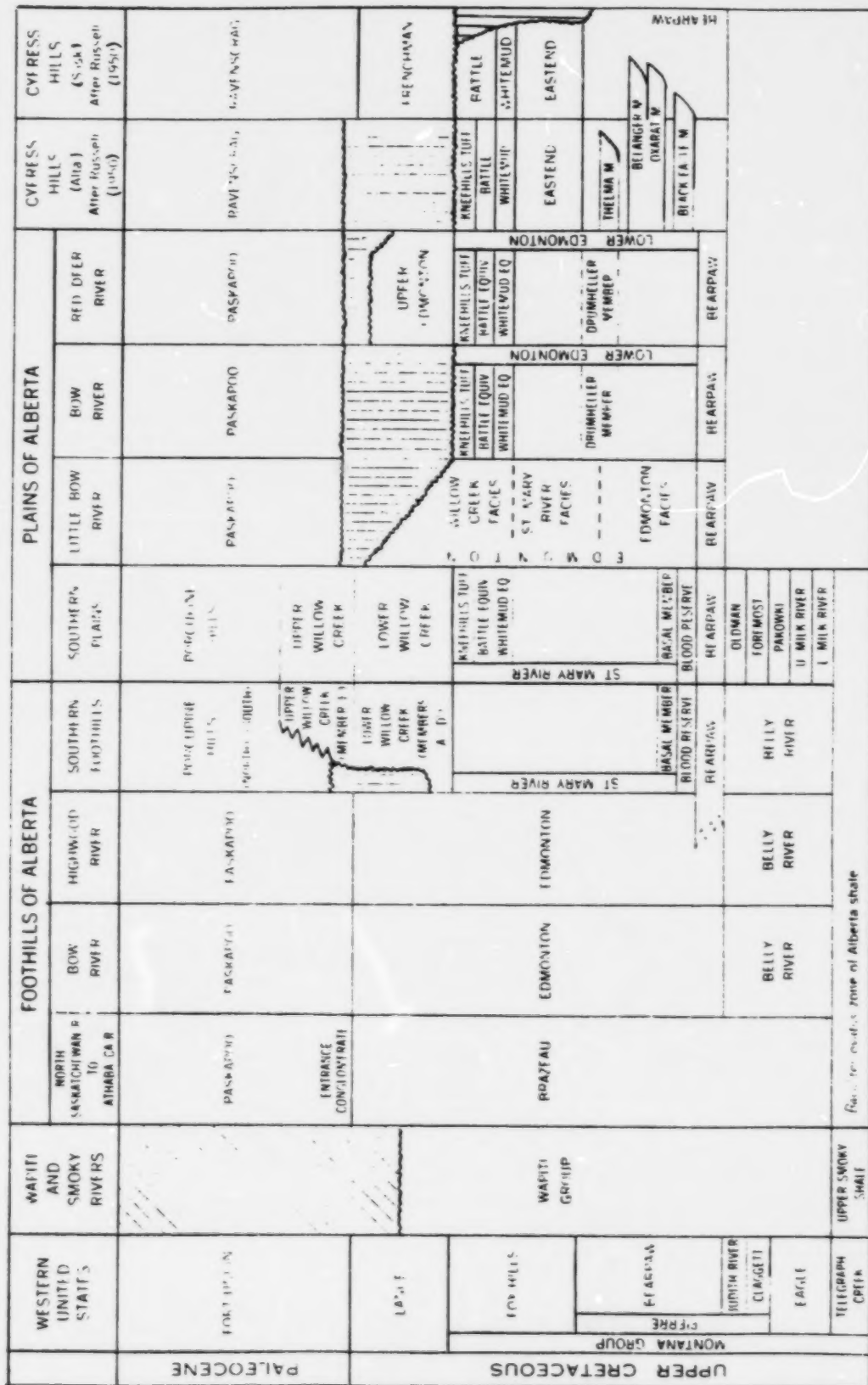


TABLE SHOWING CORRELATION OF UPPERMOST CRETACEOUS AND PALEOCENE FORMATIONS OF WESTERN ALBERTA

Figure P.-- Correlation of Upper Cretaceous and Paleocene formations of Alberta.
 From Turner (1950).

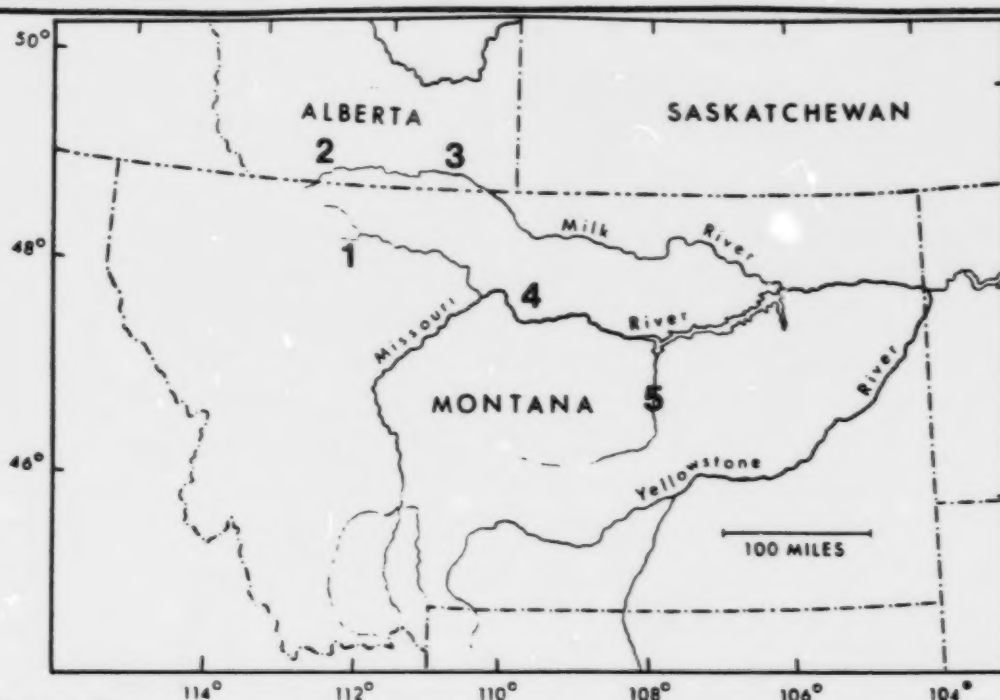


Figure 7A.-- Outline map of Montana and parts of Alberta and Saskatchewan showing locations of stratigraphic sections: 1, Toole and Pondera Counties, Montana; 2, southwestern Alberta; 3, southeastern Alberta; 4, Chouteau, Fergus and Blaine Counties, Montana; 5, Petroleum and Garfield Counties, Montana.

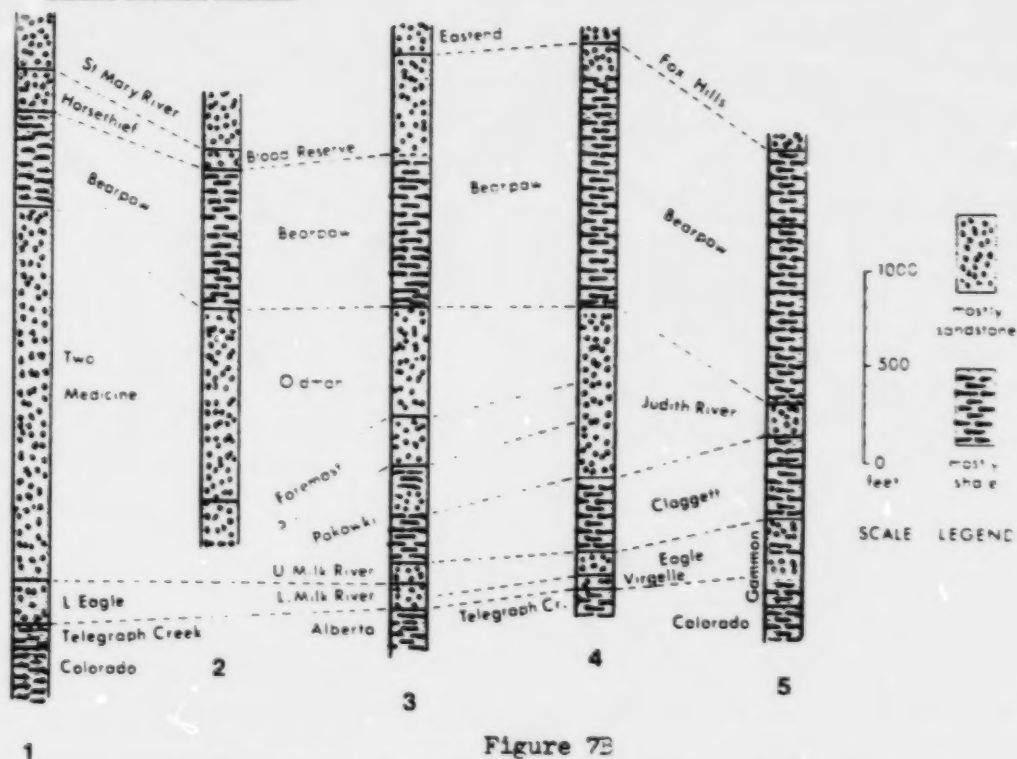


Figure 7B

Columnar Sections of Montanan formations in parts of southern Alberta and Montana, showing physical correlation. Section 1: Toole and Pondera Counties, Montana (Stebinger 1914). Section 2: southwestern Alberta (Russell 1940). Section 3: southeastern Alberta (Russell 1940). Section 4: Chouteau, Fergus and Blaine Counties, Montana (Stanton and Hatcher 1905; Pierce and Hunt 1937; Hearn *et al.* 1964). Section 5: Petroleum and Garfield Counties, Montana (Johnson and Smith 1964; Jensen and Varnes 1964).

From Russell, 1970.

Stratigraphic relationships (continued)

with the Edmonton Formation has been confirmed by many authors (e.g. Russell, 1932a; Russell and Landes, 1940; Tozer, 1956 and Russell, 1964).

The Willow Creek Formation is a thick succession that Douglas (1951) divided into members A to E. As discussed previously, the stratigraphic position of the Willow Creek Formation has been the subject of considerable debate, especially with respect to its age. Tozer (1956) demonstrated that the Cretaceous-Tertiary boundary was within the Willow Creek Formation. Tozer (1956, Fig. 2) placed the boundary at the top of Member D whereas Russell (1965) suggested that the Cretaceous-Tertiary boundary was in or at the base of Member D. To the north, members A to D of the Willow Creek Formation pass laterally into the Edmonton Formation (Fig. 8). The upper part of the Willow Creek Formation (Member E of Douglas, 1951) is Paleocene age and is equivalent to the basal part of the Paskapoo Formation and the Ravenscrag Formation. From the Callum Creek map area northward, the Willow Creek Formation becomes progressively thinner since the upper part of the formation was removed by erosion (descriptive notes with GSC map 982A).

The overlying Porcupine Hills Formation is entirely of Paleocene age and is the lateral equivalent of the Paskapoo Formation and the Ravenscrag Formation (Fig. 8).

FLORA

FLORA

The most detailed analysis of the flora from the Cretaceous and Paleocene Formations of western Canada is that by Bell (1949). He documented the following floras:

Bearpaw Formation: This formation has yielded only a single plant species, namely, Torreyites tyrrellii. This plant also occurs in the lower part of the Edmonton Formation.

St. Mary River Formation: Bell (1949) collected the following flora from the St. Mary River Formation in the Callum Creek map area:

Equisetum perlaevigatum Cockerell
Adiantum ? *paululum* Bell
Carpolithus (*Cycadinocarpus* ?) *ceratops* (Knowlton)
Elatocladus intermedius (Hollick)
Thuites interruptus (Newberry)
Dombeyopsis nebrascensis (Newberry)
Nymphaeites angulatus (Newberry)
N. striatus (Berry)
Antholithes (*Nymphaeites* ?) *marsilioides* Bell
Leguminosites stagnum Bell
Typa sp. Dorf

Of these 11 species, 4 are in common with the flora of the Lower Edmonton Formation, namely Elatocladus intermedius, Equisetum perlaevigatum, Thuites interruptus and Nymphaeites angulatus.

There appears to be no specific reference to plants occurring in the St. Mary River Formation which outcrops along the valleys that will be flooded once the dam is built.

Willow Creek Formation: A few plants have been recorded from the upper part of the formation that occurs on Willow Creek in SW $\frac{1}{4}$ sec. 1, tp. 13, rge. 28, W. 4th mer. They are:

Equisetum sp.
Carpolithus (*Ginkgoites* ?) *selwyni* Bell
Androvaetia calenulata Bell
Elatocladus (*Taxodites* ?) *tinajorum* (Heer)
Platanus raynoldsii Newberry

Hage made a small collection of plants from strata that outcrop near the mouth of the Crowsnest River. Hage considered the strata part of the Porcupine Hills Formation. Bell (1949) located the outcrops in question and recollected the fauna. He argued that the stratigraphic position of the fauna was debatable and might in fact be in the upper part of the Willow Creek Formation. The flora comprises:

Elatocladus (*Cryptomerites* ?) *nordenskioldi* (Heer)
Platanus raynoldsii Newberry
Pterospermiles haguei ? Knowlton
Cornus denserensis Knowlton
Aralia alzoensis Bell
Viburnum trinervium Berry
V. lakesii Knowlton

Flora (continued)

Williams and Dyer (1930) reported the presence of a "few leaves" in the Porcupine Hills Formation. Also, Hage (1943) reported a small collection of fossil plants from the Porcupine Hills Formation in l.s. 8, sec. 34, tp. 7, rge. 1 which were considered Paleocene in age.

INVERTEBRATE FOSSILS

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INVERTEBRATE FOSSILS

The Cretaceous and Tertiary formations exposed in the study area contain abundant and varied invertebrate fossils that have been studied by many different paleontologists. Such fossils form an important component of the total fauna.

Bearpaw Formation: The Bearpaw Formation comprises shales with large calcareous concretions. The sediments originated in a marine environment. The shales themselves rarely contain fossils; however, the concretions which are up to 5 ft. (1.5m) in diameter, commonly contain large, well preserved ammonites (Williams and Dyer, 1930). Russell and Landes (1940) reported the occurrence of Baculites compressus and Acanthoscaphites nodus from the Bearpaw Formation. Pelecypods are also common, Arctica ovata being considered a characteristic Bearpaw fossil (Hare, 1943, p. 7).

There appears to be little information pertaining to the fossils that might be present in the Bearpaw Formation that crops out on the Crowsnest River in the vicinity of Lundbreck. Elsewhere in province, however, the Bearpaw Formation has yielded diverse, abundant faunas. For example, in the Manyberries area of southeast Alberta, the fauna was sufficient to permit development of a zonation by Landes (in Russell and Landes, 1940, p. 81):

Faunal Zones in the Manyberries Section of the Bearpaw Formation

	Feet
Zone with several species of <u>Acanthoscaphites</u> ; several species of <u>Inoceramus</u> widely distributed; <u>Placenticerus</u> not common; varied associated fauna.....	447-632
Depauperate zone; <u>Placenticerus meeki</u> , <u>Baculites compressus</u> , and <u>Inoceramus vanuxemi</u> ? only moderately common fossils.....	297-447
<u>Baculites compressus</u> , <u>B. oratus</u> , <u>Placenticerus meeki</u> , <u>P. intercalare</u> abundant; <u>Inoceramus</u> notably absent; <u>Arctica ovata</u> bed included and associated fauna rich and varied, but of different facies from that in uppermost zone.....	247-297
Large <u>Baculites compressus</u> and <u>Placenticerus meeki</u> common, but associated species few in number; no <u>Inoceramus</u>	107-247
Barren zone.....	67-107
<u>Baculites compressus</u> , <u>Placenticerus intercalare</u> , <u>P. meeki</u> common; undiversified associated fauna; <u>Inoceramus sagensis</u>	62-67
Barren zone.....	42-62
<u>Ostrea patina</u> zone.....	32-42
Barren zone.....	0-32
Base of formation	

Dowling (1917, p. 26-32) provided one of the first listings of fossils present in the Bearpaw Formation throughout its regional extent. This

Bearpaw Fossils

Fossils	Lethbridge vicinity		North slope of Cypress hills		Elsewhere
	Arctica zone	Higher beds	Arctica zone	Higher beds	
PELECYPODA					
<i>Yoldia microdonta</i> Meek.....				?	
<i>Gervillia recta</i> M. and H.....				x	
<i>Gervillia borealis</i> Whiteaves.....	x	x	x	x	x
<i>Inoceramus darabini</i> Morton.....		x	x	x	x
<i>Inoceramus balchii</i> M. and H.....			x	?	
<i>Inoceramus conzeus</i> H. and M.....				?	
<i>Inoceramus vancouverensis</i> Shumard.....				x	
<i>Inoceramus simpsoni</i> Meek.....				x	
<i>Inoceramus tenuilineatus</i> H. and M.....				x	x
<i>Inoceramus vanuzemi</i> M. and H.....					W.C.
<i>Pteria linguiformis</i> E. and S.....		x	x	x B.H.	x
<i>Pteria (Oryzoma) nebrascana</i> E. and S.....			x	x B.H.	
<i>Ostrea nasuta</i> Morton.....			B.H.?		
<i>Ostrea patina</i> M. and H.....			?	x	
<i>Ostrea subtrigonalis</i> E. and S.....		x			
<i>Gryphaea vesicularis</i> Lamarck.....			?	?	
<i>Chlamys nebrascensis</i> M. and H.....				x	
<i>Syncyclonema rigida</i> H. and M.....				x	
<i>Modiola attenuata</i> M. and H.....	x		B.H.	x B.H.	
<i>Volzella meeki</i> (E. and S.) Meek.....				x	
<i>Liopistha (Cymella) undata</i> M. and H.....	x		B.H.x	x B.H.	x
<i>Arctica ovata</i> M. and H.....	x		x		
<i>Arctica ovata alta</i> Whiteaves.....	x		x B.H.		
<i>Arctica ovata compressa</i> M. and H.....			x		
<i>Corbicula cytheriformis</i> M. and H.....	x				
<i>Lucina occidentalis</i> Morton.....		x	B.H.(var)	x	
<i>Lucina subundata</i> H. and M.....				x B.H.	x
<i>Protocardia borealis</i> Whiteaves.....	x		x B.H.	x B.H.	
<i>Protocardia subquadrata</i> E. and S.....	x		x	x B.H.	?
<i>Veniella subtrapeziformis</i> var. <i>dyeri</i> Williams.....				x	
<i>Callista occidentalis</i> Morton.....				B.H.	x
<i>Callista pelucida</i> M. and H.....				x B.H.	
<i>Callista (Dositopsis) deweyi</i> M. and H.....	x	x	x	x B.H.	x
<i>Mactra (Cymbophora) alta</i> M. and H.....	?		x	x	
SCAPHOPODA					
<i>Dentalium gracile</i> M. and H.....		x		?	x
GASTROPODA					
<i>Trachytroch runculum</i> H. and M.....				x	
<i>Neritina cf. wyomingensis</i> Walcott.....			B.H.		
<i>Vanikoro ambigua</i> M. and H.....				E.H.?	x
<i>Vanikoropsis tuomeyana</i> M. and H.....				x	
<i>Anchura americana</i> E. and S.....				x	?
<i>Anchura nebrascensis</i> E. and S.....			x	x	
<i>Pseudobuccinum nebrascense</i> M. and H.....					?
<i>Actaeon attenuata</i> M. and H.....				x	x
<i>Actaeon subellipticus</i> M. and H.....				x	
<i>Cinulia (Oligopycha) concinna</i> M. and H.....					x
CEPHALOPODA					
<i>Scaphites ventricosus</i> M. and H.....				?	
<i>Acanthoscaphites nodosus</i> Owen var. <i>brevis</i> Meek.....		x	var.?		x W.C.
<i>Baculites compressus</i> (Say).....	x	x	x	x	x W.C.
<i>Baculites grandis</i> H. and M.....				x	
<i>Baculites crickmayi</i> Williams.....				x	
<i>Platoniceras meeki</i> Boehm.....	x	x	x	x	
<i>Platoniceras intercalare</i> M. and H.....	x	x			W.C.
<i>Rhabdoceras halli</i> M. and H.....				x	
CRUSTACEA					
<i>Macrura crustacea</i>			B.H.		

B.H. = Bullhead butte

W.C. = Woodpile coulée

Figure 9.-- List of fossils from the Bearpaw Formation as identified by Dyer (in Williams and Dyer, 1930, p. 39).

Invertebrate Fossils of the St. Mary River Formation

	Belly River	Edmon- ton	Willow Creek	Paska- poo	Lance	Fort Union
<i>Unio danae</i> M. and H.....	x	x	x	x	x	x
<i>Sphaerium formosum</i> M. and H.....	x	x	x	x		x
<i>Sphaerium planum</i> M. and H.....	x	x			x	
<i>Sphaerium formosum whiteavesi</i> ¹ Russell?.....	?			x		
<i>Viviparus leai</i> M. and H.....		x	x	x		x
<i>Viviparus prudentius</i> White.....			x	x		x
<i>Viviparus planolateris</i> Russell.....			x	x		
<i>Viviparus</i> sp.....		x				
<i>Campeloma multilineata</i> (M. and H.).....		x	x	x	x	x
<i>Goniobasis whittakeri</i> Dyer.....		x				
<i>Goniobasis webbi</i> Dyer.....		x	x			
<i>Physa copei</i> White.....	x	x	x	x		x
<i>Physa copei canadensis</i> Whiteaves.....	x	x	x	x		x
<i>Thaumatius limnaeiformis</i> M. and H.....		x	x	x	x	x
<i>Hydrobia recta</i> White.....		x	x	x		x
<i>Valvata filosa</i> Whiteaves.....		x	x	x		S
<i>Valvata bicornis</i> Whiteaves.....						S
<i>Patula obtusata</i> Whiteaves.....			x	x		
<i>Patula angulifera</i> ? Whiteaves.....			x			
<i>Acrolazus minutus</i> Whiteaves.....						x
<i>Anchistoma parvulum</i> Whiteaves.....						
<i>Pupa</i> sp.....						
<i>Gasteropoda opercula</i>						

¹ Reported by Russell.

S Very similar form.

Figure 10.-- Listing of fossils from the St. Mary River Formation compared to faunas found in other Cretaceous formations of Alberta. From Williams and Dyer (1930, p. 55).

Distribution of molluscan fauna of the St. Mary River formation

Localities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47		
<i>Unio stantoni</i> White																																																	
<i>U. sp. cf. U. praevius</i> White																																																	
<i>Pseudopsis</i> sp. indet.																																																	
<i>Sphaerium gietzi</i> sp. nov.																																																	
<i>S. heisterhanseni</i> Warren																																																	
<i>S. Irvingtonensis</i> Russell																																																	
<i>S. mckerni</i> Russell																																																	
<i>Pisidium squamula</i> Russell																																																	
<i>Dinorthis ptychia molanensis</i> sp. nov.																																																	
<i>D. sp. cf. D. netherfordi</i> (Russell)																																																	
<i>Virgatus prudentius prudentius</i> White																																																	
<i>V. westoni</i> sp. nov.																																																	
<i>Campana edmontonensis</i> sp. nov.																																																	
<i>Ligulodes limaeformis</i> (H. and H.)																																																	
<i>L. sanctamariensis</i> (Russell)																																																	
<i>L. sp. cf. L. tenuicincta</i> (H. and H.)																																																	
<i>L. whiteavesi</i> (Russell)																																																	
<i>Reticella</i> sp. cf. <i>R. protea</i> (Yen)																																																	
<i>Valvula flosa</i> Whiteaves																																																	
<i>Goniobasis webbi</i> Dyer																																																	
<i>Hydrobia</i> sp. indet.																																																	
<i>Pleuralimaea mckerni</i> sp. nov.																																																	
<i>Physa ceredensis</i> Whiteaves																																																	
<i>Ferussia</i> sp. indet.																																																	

Figure 11. -- Listing of fossils from the St. Mary River Formation. From Tozer (1956).

The locality numbers correspond to the localities shown on Figure 6.

Bearpaw Formation (continued)

fauna comprised brachiopods (1 species), pelecypods (38 species), gastropods (10 species), cephalopods (11 species) and crustacea (1 species). Dowling (1917) listed the localities from which he had obtained the faunas; unfortunately, not one of the localities was from the Bearpaw Formation in the vicinity of Lundbreck. Dyer (1930) also provided an extensive list of fossils known from the Bearpaw Formation (Fig. 9). Their list, however, was derived from the Bearpaw Formation which outcrops in the area around Lethbridge and on the north slope of the Cypress Hills. The fauna was good enough that Williams and Dyer (1930, p. 38) were able to derive a zonation for the formation.

The Bearpaw Formation is a richly fossiliferous formation that has yielded abundant pelecypods and ammonites. Although there is little information directly applicable to the study area, it seems reasonable to assume that it would yield abundant fossils as it does elsewhere.

St. Mary River Formation: The St. Mary River Formation contains an abundant fauna comprised mainly of pelecypods and gastropods. The basal part of the formation usually contains brackish water faunas and oysters are particularly common (Stewart, 1919; Williams and Dyer, 1930; Russell, 1932a, 1932b; Russell and Landes, 1940; Hage, 1943; descriptive notes with GSC maps 739A and 20-1967; Bell, 1949 and Tozer, 1956). Higher in the formation the brackish water fauna gives way to faunas dominated by freshwater gastropods and pelecypods (Russell, 1932a, 1932b; Russell and Landes, 1940; Bell, 1949 and Tozer, 1956). In the basal part of the formation the oyster beds commonly occur in beds that are up to 6 ft. (2 m) thick.

The pelecypods and gastropods from the St. Mary River Formation have been described or listed (Figs. 10 & 11) by Williams and Dyer (1930) Russell (1932c) and Tozer (1956).

Russell (1932a) recorded the following fossils from the basal part of the St. Mary River Formation: Ostrea glabra, Ostrea arcuatilis, Corbula perangulata and Melania wyomingensis. From sections through the St. Mary River Formation located west of Monarch and on St. Mary River Russell (1932a) recorded the following species:

Unio danae M. & H.
Sphaerium heskethense Warren
S. mclearnii Russell
S. livingstonensis Russell
Pisidium squamula Russell
Micropyrgus minutulus (M. & H.)?
Viciparus prudentius White
V. raynoldsanus (M. & H.)?
Campeloma sp.
Valvata subumbilicata (M. & H.)
Goniobasis webbi Dyer
G. whiteavesi Russell
G. sanctamariensis Russell
Physa canadensis parvaturris Russell
P. canadensis tenuis Russell
P. canadensis ampla Russell
Ferrissia minuta (M. & H.)
Paravitrea parvula (Whiteaves)
Oreohelix angulifera (Whiteaves)
O. obtusata (Whiteaves)

There is relatively little information pertaining directly to the St. Mary River Formation that outcrops on Castle River and Crowsnest River. Hage (1943, p. 7-8), however, did draw attention to an oyster bed, 4 to 6 ft. (1.2-1.8 m) thick, that occurs in the basal part of the formation on Castle River. From the available descriptions it would appear that the invertebrate fauna of the St. Mary River Formation exposed in the study area is probably closely akin to that found elsewhere.

Willow Creek Formation: The Willow Creek Formation is largely unfossiliferous (Tozer, 1956). The only significant fossil occurrences appear to be in the upper part of the formation that is exposed on Willow Creek and nearby areas. Williams and Dyer (1930) recorded a fauna of pelecypods and gastropods from the Willow Creek Formation that outcrops in the vicinity of Granum (Fig. 12). Russell (1932b) also studied the fauna from the localities on Willow Creek and updated the identifications made by Williams and Dyer (1930). The following fauna was recorded:

<i>Unio danae</i> M. & H.	<i>Goniobasis webbi</i> Dyer
<i>Sphaerium aequale</i> Russell	<i>G. subortuosa tenuis</i> Dyer
<i>S. formosum</i> (M. & H.)	<i>G. tenuicarinata</i> (M. & H.)
<i>Hydrobia warrenana</i> (M. & H.)?	<i>Lymnaea tenuicosta</i> M. & H.
<i>Micropyrgus minutulus</i> (M. & H.)	<i>Physa canadensis media</i> Russell
<i>Viciparus leai</i> (M. & H.)	<i>P. canadensis ampla</i> Russell
<i>V. prudentius</i> White?	<i>Pseudocolumna kaydeniana</i> (Cockerell)?
<i>V. crickmayi</i> Dyer	<i>Lepsisosteus</i> sp.
<i>Campeloma nebrascense</i> (M. & H.)	<i>Stylomyledon</i> sp.
<i>Lioplax nebrascensis producta</i> (White)?	<i>Aspideretes?</i> sp.
<i>Valvata subumbilicata</i> (M. & H.)	

Willow Creek Formation (continued)

Toser (1956) also provided a list of the fossils that he recovered from the Willow Creek Formation (Fig. 13).

All of the fauna recorded from the Willow Creek Formation has come from that part of the formation which outcrops to the east of the study area on the eastern limb of the Alberta Syncline. There appears to be no record of invertebrate fossils from the Willow Creek Formation that outcrops in the area that will be flooded once the dam has been built.

Porcupine Hills Formation: The Porcupine Hills Formation is essentially unfossiliferous since only a few species of pelecypods and gastropods have been recovered from the formation. Stewart (1919), for example, noted that there were only a few gastropods and Unio in the formation. Russell (1932c) and Russell and Landes (1940) regarded the formation as being unfossiliferous apart from rare, poorly preserved freshwater pelecypods and gastropods. Williams and Dyer (193) recorded Viviparus, Physa canadensis and Unio danae from the Willow Creek Formation.

Distribution of molluscan fauna of the Willow Creek formation
(lower part)

	Localities																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
<i>Unio stantoni</i> White					x		x													x			
<i>Sphaerium gietzi</i> sp. nov.																							
<i>S. heckerthense</i> Warren					?	?					?		x										
<i>Dimorphoptychia</i> sp. cf. <i>D. rutherfordi</i> (Russell)	x																						
<i>Viviparus prudentius prudentius</i> White												x											
<i>V. prudentius willevensis</i> subsp. nov.		x	x							x		x	x	x					x	x			
<i>V. westoni</i> sp. nov.				x	x	x		x			x												
<i>Campeloma edmontonensis</i> sp. nov.											?												
<i>Lioplacodes limnaeiformis</i> (M and H)											?												
<i>L. sanctamariensis</i> (Russell)					?																		
<i>L. sp. cf. L. tenuicarinata</i> (M and H)				x							x	x											
<i>Reesidella</i> sp. cf. <i>R. protea</i> (Yen)																	x						x
<i>Valvata filosa</i> Whiteaves		x	x	x							x						x						x
<i>Hydrobia</i> sp. indet.		x	x	x																			
<i>Pleurolimnaea mclernani</i> sp. nov.																	x						x
<i>Physa canadensis</i> Whiteaves								x									x						x
<i>Ferrissia</i> sp. indet.									x														x
<i>Polygona parvula</i> (Whiteaves)			x																				
<i>Pseudocolumna ? spiziei</i> sp. nov.	x	x	x	x					?					x			x	x	x				

Figure 13.-- Listing of fossils from the Willow Creek Formation.
From Tozer (1956).

Invertebrate Fossils of the Willow Creek Formation

	Belly River	St. Mary River	Edmonton	Paskapoo	Lance	Fort Union
<i>Unio denae</i> M. and H.	x	x	x	x	x	x
<i>Unio senectus</i> White	x			x		
<i>Unio subspatulatus</i> M. and H.	x			x		
<i>Unio albertensis</i> Whiteaves						
<i>Corbula subtrigonalis</i> M. and H.	x		x			
<i>Sphaerium formosum</i> M. and H.	?	x	x	x		x
<i>Viviparus loci</i> M. and H.		x	x	x		x
<i>Viviparus prudentius</i> White				x		x
<i>Viviparus trochiformis</i> M. and H.				x		x
<i>Viviparus crickmayi</i> Dyer			x			
<i>Viviparus cf. planolatus</i> Russell		x		x		
<i>Campeloma producta</i> White				x		x
<i>Campeloma multifineata</i> (M. and H.)		x	x	x	x	x
<i>Goniobasis subtrigona tenuis</i> Dyer						
<i>Goniobasis tenuicarinata</i> M. and H.			x	x		x
<i>Goniobasis webbi</i> Dyer		x	x			
<i>Theumatostus limnaeiformis</i> M. and H.		x	x	x		x
<i>Hydrobia recta</i> White		x	x	x		x
<i>Valvata filosa</i> Whiteaves		x	x	x		x
<i>Limnaea tenuicostata</i> M. and H.			x	x		x
<i>Patula obtusata</i> Whiteaves		x		x		
<i>Patula angulifera</i> Whiteaves		x		x		
<i>Columna cf. teres</i> M. and H.			x	x		x
<i>Physa copei</i> White	x	x	x	x		?
<i>Physa copei canadensis</i> Whiteaves	x	x	x	x		
<i>Acroloxus</i> sp.						

8 Similar form.

Figure 12. - Listing of fossils from the Willow Creek Formation compared to faunas found in other Cretaceous formations of Alberta. From Williams and Dyer (1930, p. 61).

VERTEBRATE FOSSILS

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VERTEBRATE FOSSILS

General statement: In 1965 Langstone pointed out that, based on a literature search to 1965, the dinosaurs from Alberta accounted for about 40% of the known Upper Cretaceous dinosaur fauna of the world. In addition, Langston (1965) showed that the Cretaceous strata of Alberta contains a vast array of other vertebrates (Fig. 14). Russell (1964, p. 15) pointed out that the Edmonton Formation and the Oldman Formation contain a wealth of vertebrates and in particular dinosaurs (Fig. 15). The Oldman Formation does not occur in the area that will be flooded once the dam has been built and thus need not enter into these considerations. The Edmonton Formation is extremely relevant to the discussion because it is the lateral equivalent of the St. Mary River Formation and the lower part of the Willow Creek Formation.

The study area encompasses the Bearpaw Formation, the St. Mary River Formation, the Willow Creek Formation and the Porcupine Hills Formation. At the time of Langston's (1965) compilation only the St. Mary River Formation vertebrate fauna was considered important enough to be included in his comparison of Cretaceous vertebrates from different formations in Alberta. Langston (1965) indicated the presence of Elasmobranch fishes, "Gonad" fishes, turtles, mosasaurs, champosaur, crocodiles, horned dinosaurs and carnivorous dinosaurs in the St. Mary River Formation of Alberta (Fig. 14). Significantly, most of the vertebrates recorded from the St. Mary River Formation also occur in the Lower and Upper parts of the Edmonton Formation.

Unfortunately it has not been possible to verify all of the vertebrate occurrences in the St. Mary River Formation as indicated by Langston, despite checking the references that he listed.

Belly River Formation: The Belly River Formation is an important sequence from the point of view of vertebrate fossils, especially since dinosaur eggshells have been found at two localities close to the study area. Braman (1985, pers. comm.) places these locations at LSD 160072W5 and LSD 040082W5. It is not known if the thin fault slice that occurs in the Crowsnest River near Lundbreck (Fig. 2) has yielded any fossils of this type.

TAXA	STRATAL UNITS				STRATAL UNITS				STRATAL UNITS			
	UPPER MILK RIVER FORMATION	FOREMOST FORMATION	OLDMAN FORMATION	LOWER EDMONTON MEMBER	UPPER EDMONTON MEMBER	ST. MARY RIVER FORMATION	UPPER MILK RIVER FORMATION	FOREMOST FORMATION	OLDMAN FORMATION	LOWER EDMONTON MEMBER	UPPER EDMONTON MEMBER	ST. MARY RIVER FORMATION
ELASMOBRANCH FISHES												
<i>Lamia</i>	*	*	*	*	*	*	?	*	*	*	*	*
<i>Palaeospina</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Myledaphne</i>	*	*	*	*	*	*		*	*	*	*	*
"GANOID" FISHES												
<i>Acipenser</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Lepisosteus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Protomia</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Belonostomus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Kindia</i>	*	*	*	*	*	*		*	*	*	*	*
TELEOST FISHES												
Genera indet.	*	*	*	*	*	*		*	*	*	*	*
AMPHIBIANS												
<i>Schapherpeton</i>	*	*	*	*	*	*		*	*	*	*	*
Genera indet.	*	*	*	*	*	*		*	*	*	*	*
TURTLES												
<i>Aspideretia</i>	?	*	*	*	*	*		*	*	*	*	*
<i>Neurankylus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Boremys</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Bacra</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Adocus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Basilemys</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Compsemys</i>	*	*	*	*	*	*		*	*	*	*	*
MOSASAURS												
Genus indet.	*	*	*	*	*	*		*	*	*	*	*
CHAMPSOSAUR												
<i>Champsosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
CROCODILE												
<i>Leidyosuchus</i>	*	*	*	*	*	*		*	*	*	*	*
LIZARDS												
<i>Palaeosaurops</i>	*	*	*	*	*	*		*	*	*	*	*
Genera indet.	*	*	*	*	*	*		*	*	*	*	*
DUCKBILL DINOSAURS												
<i>Gryposaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Prosaurolophus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Brachylophosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Saurolophus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Corythosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Lambeosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Parasaurolophus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Procheneosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Cheneosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Hypacrosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Edmontosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Anatosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Hadrosaurinae</i> indet.	*	*	*	*	*	*		*	*	*	*	*
HORNED DINOSAURS												
<i>Eoceratops</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Brachyceratops</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Monoclonius</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Centrosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Styracosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Chasmosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Anchiceratops</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Leptoceratops</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Arrhinoceratops</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Pachyrhinosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Triceratops</i>	*	*	*	*	*	*		*	*	*	*	*
Genera indet.	*	*	*	*	*	*		*	*	*	*	*
ARMORED DINOSAURS												
<i>Palaeoscincus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Exoplocephalus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Anodontosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Panoplosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Edmontonia</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Scelosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Dyoplosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Ankylosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
CARNIVOROUS DINOSAURS												
<i>Dromaeosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Gorgosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Albertosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Tyrannosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Ornithomimus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Struthiomimus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Ornithomimipus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Chirostenotes</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Macrophalangia</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Stenonychosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Troodon</i>	*	*	*	*	*	*		*	*	*	*	*
Genera indet.	*	*	*	*	*	*		*	*	*	*	*
OTHER DINOSAURS												
<i>Parkosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Thescelosaurus</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Stegoceras</i>	*	*	*	*	*	*		*	*	*	*	*
" <i>Laosaurus</i> "	*	*	*	*	*	*		*	*	*	*	*
BIRD ?												
<i>Caenagnathus</i>	*	*	*	*	*	*		*	*	*	*	*
MULTIBERCULATE												
<i>Cimolomys</i>	*	*	*	*	*	*		*	*	*	*	*
MARSUPIALS												
<i>Eodelphis</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Boreodon</i>	*	*	*	*	*	*		*	*	*	*	*
? <i>Diaphorodon</i>	*	*	*	*	*	*		*	*	*	*	*
<i>Stagodon</i>	*	*	*	*	*	*		*	*	*	*	*
? <i>Delphodon</i>	*	*	*	*	*	*		*	*	*	*	*
INSECTIVORE												
? <i>Leptictidae</i> indet.	*	*	*	*	*	*		*	*	*	*	*
CARNIVORE												
? <i>Miacidae</i> indet.	*	*	*	*	*	*		*	*	*	*	*

Figure 14.-- Comparison of vertebrate fossils from the important vertebrate-bearing formations of Alberta. From Langston (1965).

Vertebrate fauna of the lower and middle parts of the Edmonton formation

Reptilia

Basilemys sp.
Aspideretes sp.
Leurospondylus ultimus Brown
Champsosaurus albertensis Parks
Leidyosuchus? sp.
Albertosaurus sarcophagus Osborn
A. arctunguis Parks
Struthiomimus brevitertius Parks
S. currellii Parks
S. ingens Parks
Ornithomimus edmontonensis Sternberg
Anatosaurus edmontoni (Gilmore)
Edmontosaurus regalis Lambe
Saurolophus osborni Brown
Hypacrosaurus altispinus Brown
Cheneosaurus tolmansensis Lambe
Parksosaurus warreni (Parks)
Stegoceras sp.
Anchiceratops ornatus Brown
A. longirostris Sternberg
Arrhinoceratops brachyops Parks
Edmontonia longiceps Sternberg
Anodontosaurus lambei Sternberg

Chondrichthyes

Myledaphus sp.

Lamna sp.

Actinopterygii

Acipenser sp.

Lepidosteus sp.

Diphyodus longirostris Lambe

Vertebrate fauna of the Upper Edmonton beds (Lance equivalent)

Chondrichthyes

Palaespinax ejuncidus Lambe

Myledaphus sp.

Actinopterygii

Lepidosteus sp.

Acipenser sp.

Kindleia fragosa Jordan

Stylomyleodon sp.

Reptilia

Champsosaurus sp.

Tyrannosaurus sp.

Anatosaurus sp.

Thescelosaurus edmontonensis Sternberg

Leptoceratops gracilis Brown

Triceratops albertensis Sternberg

Ankylosaurus sp.

Mammalia

Diaphorodon? sp.

Stagodon sp.

Figure 15.-- Listing of vertebrate fossils from the Edmonton Formation. From Russell (1964).

Vertebrate fossils (continued)

Bearpaw Formation: The Bearpaw Formation is a marine sequence which contains a fauna dominated by pelecypods and ammonites. Russell and Landes (1940) noted, however, that scattered bones of plesiosaurs and mosasaurs are known from the Bearpaw Formation. They also noted that there were unconfirmed reports of a mosasaur skeleton being found in the formation in the vicinity of Manyberries (Russell and Landes, 1940, p. 81-82). In recent years four partial skeletons of mosasaurs have been recovered from the Bearpaw Formation (Braman, 1985, pers. comm.). These specimens were recovered from a locality near Lethbridge (1 specimen), a locality near Dinosaur National Park (1 specimen) and a locality near Manyberries (2 specimens). The Manyberries locality has also yielded isolated vertebrate of short- and long-necked vertebrate (Braman, 1985, pers. comm.). Fish are also known from nodules that occur in the formation in the vicinity of Manyberries and near Medicine Hat (Braman, 1985, pers. comm.).

The status of the Bearpaw Formation in the valley of the Crowsnest River near Lundbreck is unknown.

St. Mary River Formation: Dinosaur bones are known from the St. Mary River Formation (Williams and Dyer, 1930; Russell, 1930, 1932c, 1950, 1964). They are, however, poorly preserved and seldom good enough to permit identification (Russell, 1964). This appears to be particularly true for the St. Mary River Formation which outcrops in the area that will be flooded following construction of the dam.

The St. Mary River Formation of Montana has yielded a small ceratopsian skeleton (Russell, 1932c, 1964) which Brown and Schlaikjer (1942) called Leptoceratops cerorhynchus. Sternberg (1951) subsequently assigned this species to Montanoceratops.

A large number of hadrosaur bones have been found in the St. Mary River Formation of the Cardston area (Russell, 1964).

At Scabby Butte (near Nobleford), to the north of the study area, the St. Mary River Formation has yielded mammal teeth (Russell, 1962) and mammals (Sloan and Russell, 1974) as well as vertebrate bones (Russell, 1964) and the skull of Pachyrhinosaurus canadensis which

Class ELASMOBRANCHII

Order Isuriformes
 Orectolobidae
Squatirhina americana Estes

Order Squatinoidei
 Squatinidae
Squatina Risso, sp. indet.

Order Rajiformes
 Dasyatidae
Myledaphus bipartitus Cope

Class OSTEICHTHYES

Order Amiiformes
 Amiidae
Amia cf. *A. fragosa* (Jordan)

Order Aspidorhynchiformes
 Aspidorhynchidae
Belonostomus cf. *B. longirostris* (Lambe)

Order Lepisosteiformes
 Lepisosteidae
Lepisosteus Lacépède, sp. indet.

Order Elopiformes
 Phyllodontidae
Paralbula casei Estes

Order Perciformes
 Sciaenidae
Platacodon cf. *P. nanus* Marsh

Class AMPHIBIA

Order Urodela
 Batrachosauroididae
Opisthotriton Auffenberg, sp. indet.

Class REPTILIA

Order Testudines
 Trionychidae
Aspideretes Hay, sp. indet
 Baenidae
Boremys Lambe, sp. indet

Order Eosuchia
 Champsosauridae
Champsosaurus Cope, sp. indet

Order Squamata
 Mosasauridae
Plioplatecarpus Dollo, sp. indet

Order Crocodilia
 Crocodylidae
Leidyosuchus Lambe, sp. indet.
 Crocodilia, gen. and sp. indet.

Order Saurischia
 Tyrannosauridae, gen. and sp. indet.
 ?Coeluridae, gen. and sp. indet.
 Ornithomimidae, gen. and sp. indet.
 Troodontidae
Troödon Leidy, sp. indet.

Order Ornithischia
 Hadrosauridae
Edmontosaurus Lambe, sp. indet
 Ceratopsidae
Pachyrhinosaurus canadensis Sternberg
Anchiceratops Brown, sp. indet.
 Nodosauridae
Edmontonia cf. *E. longiceps* Sternberg

Figure 16.- Summary of fauna recovered from the St. Mary River Formation at Scabby Butte. From Langston (1975, p. 1577).

St. Mary River Formation (continued)

was described by Sternberg (1950). Although Russell (1964) assigned the strata of this area to the St. Mary River Formation, Sternberg (1950) treated it as part of the Edmonton Formation.

Langston (1975) documented a diverse vertebrate fauna from the St. Mary River Formation that outcrops in the Scabby Butte area (Fig. 16).

Willow Creek Formation: From the point of view of vertebrate fossils the Willow Creek Formation is very poorly known. There are a few tantalizing references to such faunal elements, enough to suggest that there may be a richer vertebrate fauna in this formation than is generally thought. Russell (1932a) described the Willow Creek Formation on Willow Creek, Mosquito Creek and Little Bow River and reported the occurrence of dinosaur remains from an outcrop in sec. 11, tp. 14, rge. 23, W. 4th mer. Tozer (1956) documented the occurrence of a "definite dinosaur bone" from a bed 1,000 ft. (307.5 m) above the base of the Willow Creek Formation on the left side of the Crowsnest River in l.s. 8, sec. 32, tp. 7, rge. 1, W. 5th mer. Russell (1965) noted that Dawson had found a turtle in the Willow Creek Formation; however, Russell was unable to find any further specimens.

In recent years the Willow Creek Formation of the Study area has been searched for vertebrates by Dr. P. Currie from the Tyrrell Museum. In 1982 he and his party met with success when they discovered two dinosaur skeletons. The first, which may be Leptoceratops was found in the southeast quarter of sec. 27, tp. 7, rge. 30, W. 4th mer. The second, a carnivorous dinosaur resembling Tyrannosaurus rex was found in subdivision 14, sec. 32, tp. 7, rge. 1, W. 5th mer. Both of these specimens are important because (1) they demonstrate that the potential of the Willow Creek Formation for yielding vertebrates is probably far greater than had been previously suspected and (2) according to Dr. Currie these forms are different from those found in Dinosaur Park - thus, such specimens have the potential of greatly enhancing our knowledge of the dinosaurs of Alberta.

Porcupine Hills Formation: As far as can be ascertained from the literature this formation has little potential of yielding vertebrate faunas. Nevertheless, this formation passes northwards into the Paskapoo Formation, a formation that contains a diverse vertebrate fauna. Thus, there is the possibility that vertebrates may be present in the Porcupine Hills Formation. Naylor (pers. comm. via D. Braman, 1985) suggested that there are two known mammal sites in the Porcupine Hills Formation, one near Cochrane and the other north of Cochrane. It should be noted, however, that this is well north of the study area and well within the area where the Paskapoo Formation is known to occur. Thus, the formational status of the Cochrane mammal localities should be treated with caution.

SUMMARY

SUMMARY

The Upper Cretaceous and Tertiary formations which crop out in the river valleys that will be flooded once the dam has been built have the potential of yielding excellent plant fossils, invertebrate fossils and vertebrate fossils. In part this assessment is based on the fossils known to have been collected from strata which crop out in the valleys of the Crowsnest River, the Oldman River and Castle River. Nevertheless, it is evident that the Bearpaw, St. Mary River, Willow Creek and Porcupine Hills formations that outcrop in these valleys have not been investigated as well as they should have been. From the literature it appears that little work has been done in the area over the last 15 to 20 years. Study of these formations in other parts of Alberta and Montana have shown that they have the potential of yielding significant fossil material.

Plants, known from strata which crop out on Crowsnest River, were studied in detail by Bell (1949). Nevertheless, further collecting and study would probably yield significant new information. Invertebrate fossils, especially pelecypods and gastropods, are common throughout the Bearpaw Formation, the St. Mary River Formation and parts of the Willow Creek Formation. Ammonites are probably present in the Bearpaw Formation, although this is not expressly stated for that part of the formation which crops out along Crowsnest River in the vicinity of Lundbreck. Certainly the status of this part of the Bearpaw Formation should be checked with respect to its ammonite content. Such an assessment would be especially pertinent if the large diameter ammonites proved to be present in the area. The pelecypod and gastropod faunas of the area are also spectacular in their own right. Nevertheless, it would appear that similar, equally well preserved faunas are present in areas outside that which will be flooded.

The studies of the vertebrates with respect to the Upper Cretaceous strata of the area is less certain. There are reports of vertebrates from the Bearpaw Formation in other parts of Alberta but it is not known if any occur in the formation that is around Lundbreck. It would certainly be worth spending some time investigating this formation. The St. Mary River Formation is known to contain dinosaur bones; however, they are

Summary (continued)

generally poorly preserved and not identifiable. It might however, be worth looking at the strata once again since better preserved specimens are known from this formation in other areas. On the basis of information available in the literature, the Willow Creek Formation appears to offer little prospect of yielding vertebrate fossils. Nevertheless, there is sufficient evidence to suggest that considerable time be spent investigating this formation. This is especially true in view of the success that Dr. P. Currie of the Tyrrell Museum had last year in locating two well preserved dinosaurs from the Willow Creek Formation of the study area. The Porcupine Hills Formation appears to offer little prospect of yielding vertebrate fossils.

In the vicinity of Lundbreck there is a thin slice of the Belly River Formation. The status of the formation with respect to fossils is not known since it has not been specifically dealt with in the literature. In view of the fact that the Belly River Formation has yielded an extensive, well preserved vertebrate fauna elsewhere in Alberta, the formation should be viewed in some detail. Certainly it needs assessment in the field.

PHASE II FIELDWORK PROGRAM

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PHASE II
FIELDWORK PROGRAM

Based on the literature search summarized in this report it is evident that further field work is required before a full assessment of the paleontological potential of the area can be achieved. Specifically, the following points need resolving:

- (1) the status of the Belly River Formation in the vicinity of Lundbreck. A total assessment of all faunal elements of the formation is required since there is no specific information available for this formation in this area. It is especially critical in view of the known occurrences of dinosaur eggs in the Belly River Formation at localities near the study area. This may well be a futile effort since there appears to be very poor exposure of the formation in the river valley near Lundbreck. Nevertheless, in view of the extreme importance of the type of material that could be found, it is essential that this area be investigated.
- (2) the status of the Bearpaw Formation that crops out in the western part of the study area. This is important from two points of view: (a) to see if the outcrops on the Crowsnest River contain the large ammonites that the formation is known to contain elsewhere and (b) to see if the outcrops on the Crowsnest River contain any vertebrate remains akin to the mesosaur and plesiosaur bones found in this formation in the vicinity of Lethbridge, Maryberries and Dinosaur National Park.
- (3) the status of the St. Mary River Formation that crops out on Crowsnest River. This formation should yield additional vertebrate material including dinosaur bones. Although the literature indicates that this material is generally poorly preserved it is worth noting that this formation has yielded well preserved, diverse faunas in other parts of the province. This formation should receive considerable attention to see if similar faunas occur.

Fieldwork program (continued)

- (4) the status of the Willow Creek Formation in its outcrops along Crowsnest River and Castle River. It is evident from this study that the full potential of this formation has yet to be realized. Prior to four or five years ago very few vertebrate fossils were known from this formation. Given that it is equivalent to the upper part of the Edmonton Formation which is well known for its abundant, diverse, well preserved vertebrate fauna there is the potential for important discoveries. This was emphasized by Dr. P. Currie of the Tyrrell Museum who recovered two dinosaurs from the formation in 1982. The fact that they appear to be different from those known in the Edmonton Formation adds further importance to them. Certainly, this formation, above all others, deserves critical assessment in the field.
- (5) the status of the Porcupine Hills Formation in its outcrops on Crowsnest River, Oldman River and Castle River. Based on the literature review it would seem that this formation is largely unfossiliferous. It is evident, however, that geologists have not spent a great deal of time searching for fossils in this formation. Thus, in some respects it is an unknown entity. In the Paskapoo Formation mammal-bearing beds commonly occur in close stratigraphic proximity to oyster beds. Thus, as a first step the formation of the study area should be surveyed for the occurrence of oyster beds. Certainly it would be worth spending some time on the formation to fully verify its status.

PALYNOLOGICAL SAMPLING

The formations exposed in the study area would appear to be ideally suited for detailed palynological study. The formations of the study area embrace almost 10,000 ft. (3706 m) of strata and considerable amounts of shale and siltstone which should have a high potential of yielding palynological material. The thickness of the sequence poses some problems since detailed sampling at intervals of 5 to 10 ft. (1.5 to 3.0 m) would

Fieldwork program (continued)

yield an extremely large number of samples and require considerable collecting time in the field. Clearly, the collecting program would have to be designed with this in mind. It may well be that a two stage program would be required. This first part may involve a limited number of samples from widely scattered areas, the aim being to assess the material that was present. Based on this it might be possible to pinpoint specific areas of interest - for example, the Cretaceous - Tertiary boundary. Obviously, such a program would have to be designed in consultation with the palynologist who would ultimately be responsible for preparing the samples and identifying the resultant material.

DEPOSITIONAL ENVIRONMENTS

The identification of specific depositional environments based on the evidence available in the rocks can be of considerable use in the locating of fossils. This is based on the simple premise that certain fossils commonly display a distinct tendency to occur only in rocks that accumulated under particular conditions. The information available in the literature is, in many respects, sketchy and inadequate for the present needs. For example, the depositional environments are commonly given on the basis of the whole formation and commonly on a very general level. It has been impossible, on the basis of the literature survey, to provide a detailed assessment of the original depositional environments for the rocks exposed in the study area. Any field study of this area must include this component, thus the field work should be done by geologists conversant with the methods and techniques involved with the interpretation of original depositional environments.

APPROACH TO FIELDWORK

It is evident from this study and from the comments made above that the area which will be flooded once the dam has been built is poorly known from a geological point of view and especially from a paleontological point of view. To do a detailed assessment of the study area, including verification of the geological map, documentation of the lithologies and

Fieldwork program (continued)

original depositional environments and a full assessment of the paleontological potential of the area would probably require about three to four weeks of intensive fieldwork.

Analysis of the air photographs of the study area shows that there are numerous, excellent exposures throughout the study area. In all 74 exposures have been identified (see attached map). Given the information obtained from the literature review and analysis of the air photographs it is recommended that the fieldwork be approached in the following way:

- (1) a traverse along Crowsnest River starting just above Lundbreck, covering the Bearpaw, Belly River, St. Mary River and Willow Creek formations. This sequence encompasses some of the most important strata from a paleontological point of view. Furthermore, analysis of the air photographs suggests that the exposures in the cliffs lining the river are relatively accessible, especially when compared to the cliffs exposed along Castle River and Oldman River. Thus, it is recommended that a considerable amount of field time be spent in this area.
- (2) a traverse along Castle River to its junction with the Oldman River. This traverse would span the Willow Creek and Porcupine Hills formations. Air photograph analysis suggests that the exposures, while being spectacular, may well be largely inaccessible since the cliff faces are vertical or near vertical. Nevertheless, the basal parts of the cliff exposures should be visited and investigated. Special attention should be paid to the Willow Creek Formation since this has the potential of yielding some important fossils. The Porcupine Hills Formation tends to outcrop in vertical cliffs which for the most part seem to be almost totally inaccessible.
- (3) a traverse along the Oldman River from its northern part down to dam site. This traverse would largely be in the Porcupine Hills Formation. The only exception of this would be on the northern part of the Oldman River where there are some exposures in the Willow Creek Formation. To a large extent it would appear that

Fieldwork program (continued)

this part of the succession is largely unfossiliferous. Nevertheless, some time should be spent on the sequence in order to verify this. As noted previously, the Paskapoo Formation, which is the lateral equivalent of the Porcupine Hills Formation, contains some important vertebrate fossil localities. In the Paskapoo Formation the mammal bearing units are commonly in close stratigraphic proximity to oyster beds. Thus, as a first step the Porcupine Hills Formation of the study area should be surveyed for oyster beds. It is evident from the literature that this formation may not be as important as the other formations from a paleontological point of view - this would suggest that less time be spent on it compared to the other formations.

Analysis of the air photographs suggests that many of the exposures are inaccessible from roads or tracks. Furthermore, the vertical or near vertical nature of some of the cliffs means that even if the outcrop can be reached from the road it would be impossible to view the outcrops in detail. The easiest way of approaching the exposures would be from the rivers themselves. Thus, it is suggested that the necessary geological traverses be achieved by using a boat. Such an approach would permit assessment of outcrops on both sides of the river. In some cases it would allow study of the basal strata in the vertical cliffs - strata that could not be viewed if other methods were employed. An alternative method would be to use a helicopter. This would have the advantage of speeding up the fieldwork; however, it would be more expensive and some outcrops could not be visited.

71

AIR PHOTOGRAPH ANALYSIS

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EXTENT OF ROCK EXPOSURES AS DETERMINED FROM AIR
PHOTOGRAPH INTERPRETATION

The area that is to be flooded once the dam has been built includes some spectacular exposures. All of the areas that may contain some important exposures have been identified using air photographs and marked on the air photograph mosaic. In all 74 localities have been identified on Crowsnest River, Oldman River and Castle River. The following notes are provided as a guide to each of these exposures.

Localities 1-6

These 6 localities are on the Crowsnest River and encompass those localities which span the Bearpaw Formation. This area is also supposed to contain a thin fault slice of the Belly River Formation. Thus, some of these localities may be important since this formation does have the potential of yielding important vertebrate fossils.

- Locality 1: Possibly some small outcrops at foot of hills, probably poor.
- Locality 2: Possibly some small outcrops although it is not absolutely clear from the available air photographs.
- Locality 3: As for localities 1 and 2.
- Locality 4: Good exposure in river bank.
- Locality 5: As for localities 1, 2 and 3.
- Locality 6: Appears to be poor, scattered outcrops. Potentially important since the boundary between the Bearpaw and St. Mary River formations must occur in this area.

Localities 7-14:

These localities embrace the St. Mary River Formation that outcrops along the Crowsnest River. These outcrops have the potential of yielding dinosaur bones that are, in general, poorly preserved.

- Locality 7: Small, generally poor outcrops in river bank.
- Locality 8: Appears to be good exposures on steep cliffs that form river bank. Difficult to determine accurately since this locality is in shadow on the air photographs.
- Locality 9: As for locality 8.
- Locality 10: Possibly some small outcrops at base of hills.
- Locality 11: Possibly some small outcrops at base of hills where river cuts bank.
- Locality 12: Some poor exposures in bottom part of river valley.
- Locality 13: Poor exposures in base of cliff along river bank.
- Locality 14: As for locality 13.

Localities 15-22.

These localities cover the Willow Creek Formation that is exposed along the Crowsnest River. They are important because they have the potential of yielding important dinosaur material.

Locality 15: Probably some scrappy outcrop near river.

Locality 16: Possibly some exposure in river cliffs; however, extent not known since area is in shadow on the air photographs.

Locality 17: Excellent exposure in steep to near vertical cliffs along river

Locality 18: Good exposures in low cliffs near river level.

Locality 19: Good exposure in steep cliffs.

Locality 20: Small outcrop in high part of river cliff.

Locality 21: Good exposure in steep cliff.

Locality 22: Appears to be some exposure in cliffs; however, extent unknown since area is in shadow on the air photographs.

Localities 23-41.

These localities encompass those areas on the Oldman River as far as its junction with Castle River. With the exception of locality 25 all of the outcrops are of the Porcupine Hills Formation.

Locality 23: Excellent outcrop in very steep cliffs.

Locality 24: As for locality 23.

Locality 25: Some outcrop in very steep cliffs.

Locality 26: Possibly some small outcrops in low cliff.

Locality 27: As for locality 26.

Locality 28: Some outcrop in cliffs.

Locality 29: Possibly some scattered outcrop in cliffs.

Locality 30: Generally very good exposure in steep cliffs.

Locality 31: Possibility of some small outcrops, especially near foot of cliffs.

Locality 32: Scattered outcrops near base of cliffs.

Locality 33: Possibility of some small, poor outcrops near base of cliffs.

Locality 34: May be some poor exposures.

Locality 35: Good exposure in steep cliffs.

Locality 36: Very good exposure in steep to vertical cliffs.

Locality 37: Possibly some good exposure in steep cliffs; however, area in shadow on air photograph.

Locality 38: Good exposure in steep cliffs.

Locality 39: Some scattered outcrops in river cliffs.

Locality 40: Possibly some small outcrops; however, area in shadow on air photographs.

Locality 41: Good exposure in low cliffs along river.

Localities 42-47.

These localities cover the Willow Creek Formation along Castle River. As for the situation on the Crowsnest River, these localities are important since they have the potential of yielding important dinosaur material.

Locality 42: Excellent exposure in steep cliffs.

Locality 43: Possibly very good exposures in steep to near vertical cliffs; however, full extent of exposure unknown since the area is in shadow on the air photographs.

Locality 44: Generally poor to very poor exposures in basal parts of cliffs.

Locality 45: Possibly some good exposures; however, area is in shadow on the air photographs.

Locality 46: Excellent outcrop in very steep to near vertical cliff along river bank.

Locality 47: Possibly some good exposures in very steep cliff; however, extent unknown since the area is in shadow on the air photographs.

Localities 48-74.

These localities are all in the Porcupine Hills Formation. In general they involve steep to vertical cliffs which would be very difficult to scale.

Locality 48: Excellent exposure in near vertical cliffs.

Locality 49: As for locality 48.

Locality 50: Excellent exposure in very steep cliffs.

Locality 51: Possibly some exposure in very steep cliffs; however, extent not known because area is in shadow on air photographs.

Locality 52: As for locality 48.

Locality 53: Possibly some poor exposure at base of cliffs.

Locality 54: Some exposure of beds in very steep to vertical cliffs.

Locality 55: Possibly some exposure, but difficult to tell since area is in shadow on air photographs.

Locality 56: Excellent exposure in near vertical cliffs.

Locality 57: Possibly some exposure; however, area is heavily treed and exposures not readily apparent on air photographs.

Locality 58: Excellent exposures in steep to vertical cliffs.

Locality 59: Possibly some small exposures in low cliffs.

- Locality 60: Some exposures in basal part of cliffs.
- Locality 61: Good exposures in steep cliffs.
- Locality 62: As for locality 61.
- Locality 63: As for locality 61.
- Locality 64: Possibly some exposure in steep cliffs; however, full extent not known since area is in shadow on the air photographs.
- Locality 65: Excellent exposures in steep cliff
- Locality 66: As for locality 65.
- Locality 67: Excellent exposures in steep to vertical cliffs.
- Locality 68: Small scattered outcrops at base of river banks.
- Locality 69: Good exposures at foot of hills where river is undercutting.
- Locality 70: Possibly some small outcrops.
- Locality 71: Possible some good exposures; however, full extent is unknown since the area is wooded and is largely in shadow on the air photographs.
- Locality 72: Good exposure at foot of cliff along river bank.
- Locality 73: Good to excellent exposures in steep to very steep cliffs.
- Locality 74: Scrappy outcrop.

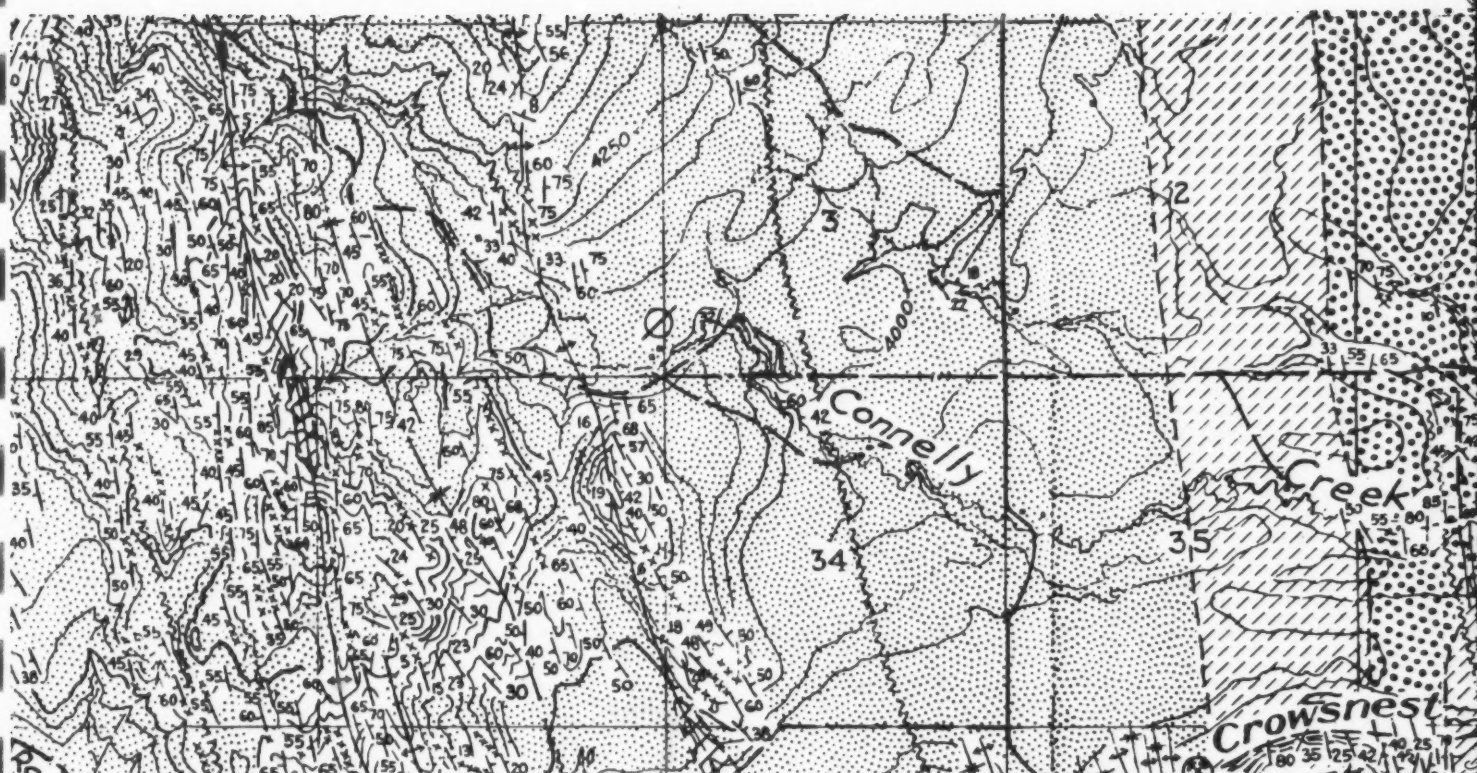
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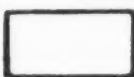
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LEGEND

TERTIARY

PALEOCENE



PORCUPINE HILLS FORMATION buff weathering cross-bedded sandstone interbedded with light and dark grey shale; thin coaly beds in basal part



WILLOW CREEK FORMATION maroon, reddish brown, and grey shale containing numerous irregular calcareous concretions and interbedded with soft grey sandstone

CRETACEOUS

UPPER CRETACEOUS



ST MARY RIVER FORMATION brown weathering coarse to fine grained cross-bedded sandstone, interbedded with grey shale and carbonaceous shale, coal



BEARPAW FORMATION dark grey marine shale with calcareous concretions



BELLY RIVER FORMATION grey cross-bedded sandstone, grey shale with concretions, bentonitic shale, thin carbonaceous beds, coal seams in upper part

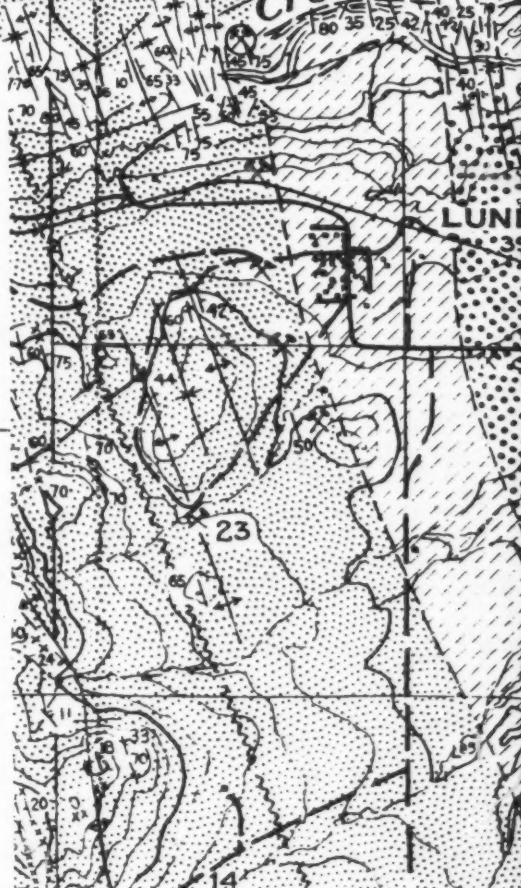
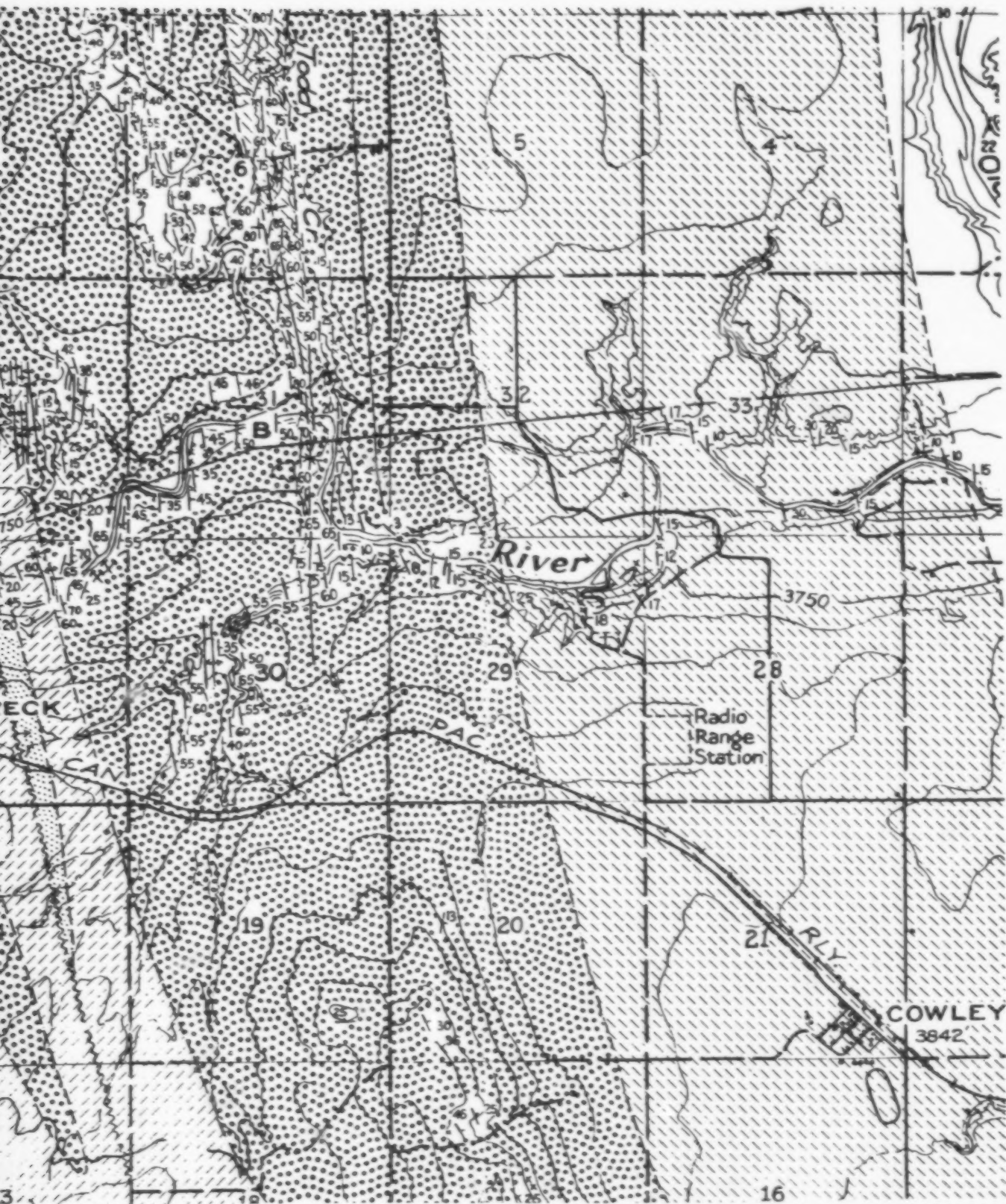
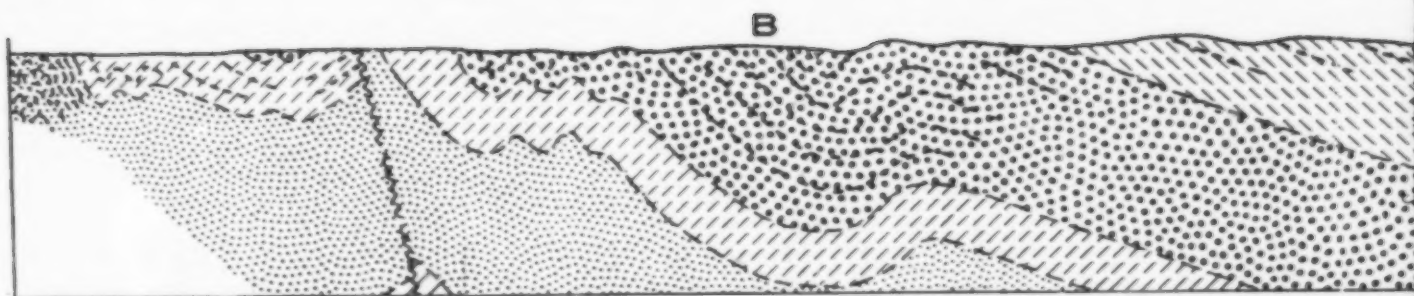


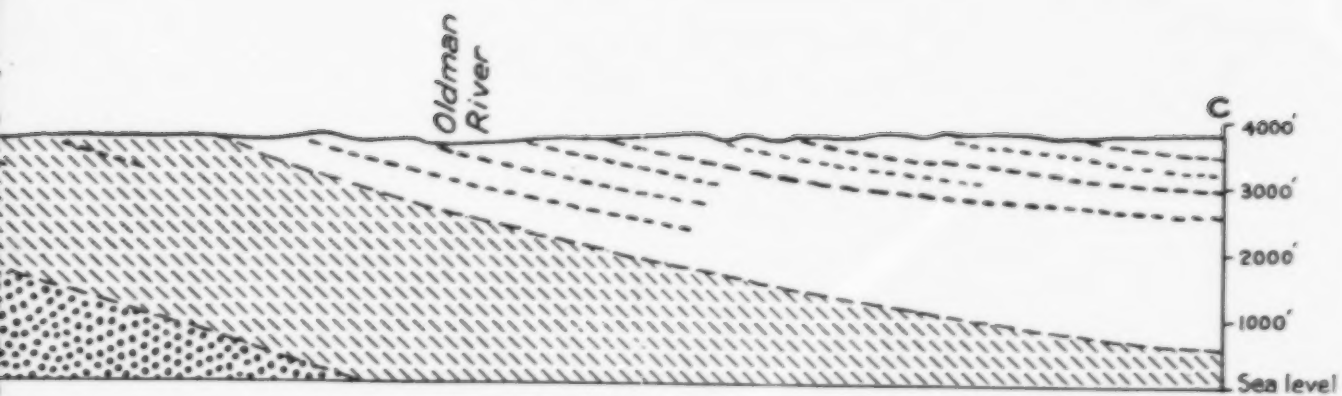
Figure 2 - Detailed geological map of study area. From Hage (1943).



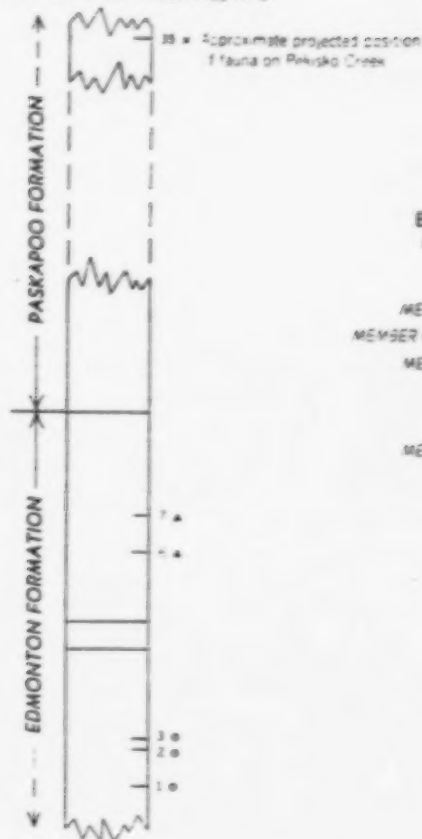


STRUCTURE SECTION ALONG LINE ABC

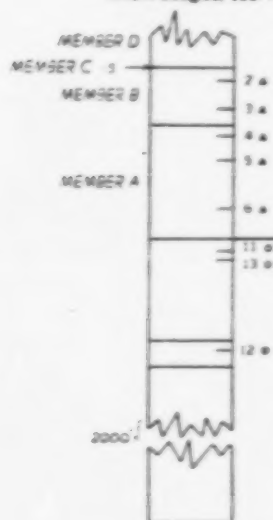
Figure 3 - Cross section through western
part of study area. From
Hage (1943).



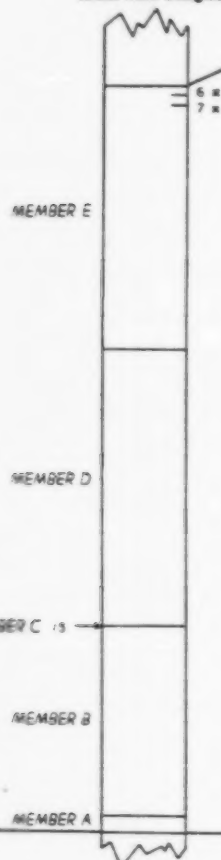
HIGHWOOD RIVER
BETWEEN LSD. 2, S. 10, AND
LSD. 10, S. 11, T. 18, R. 2, W. 5



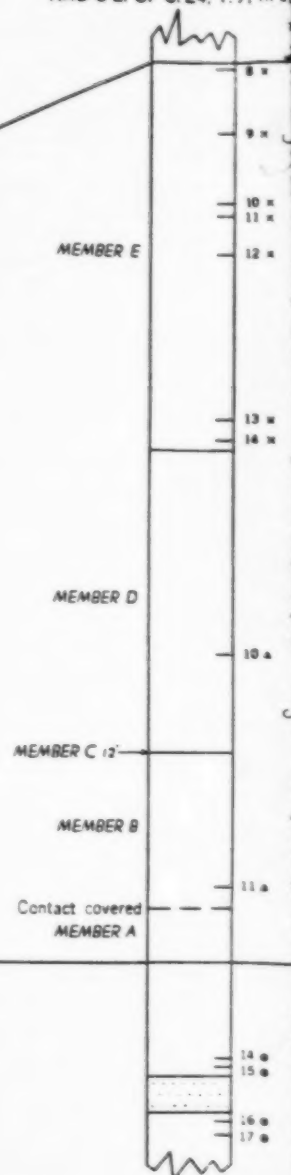
OLDMAN RIVER
BETWEEN S. 12, T. 10, R. 2,
AND S. 5, T. 10, R. 1, W. 5
(From Douglas, 1950)



CROWSNEST AND OLDMAN RIVERS
BETWEEN S. 29, AND S. 36,
T. 7, R. 1, W. 5
(Data from Douglas)



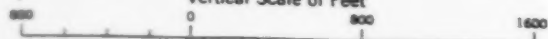
CASTLE RIVER
BETWEEN S.W. OF S. 35,
AND S.E. OF S. 24, T. 7, R. 1



LEGEND

- Figures refer to fossil localities
- Paskapoo (Paleocene) fauna
- Lower Willow Creek (Upper Cretaceous) fauna
- St. Mary River (Upper Cretaceous) fauna
- "Blocky Sandstone" member
- 15
x
x
x
x

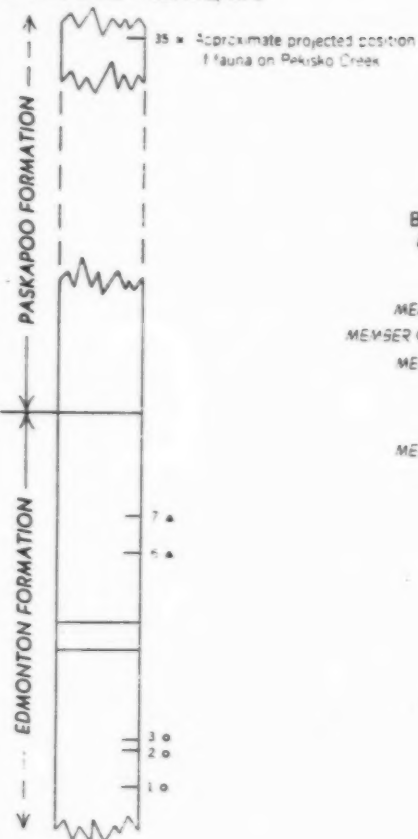
Vertical Scale of Feet



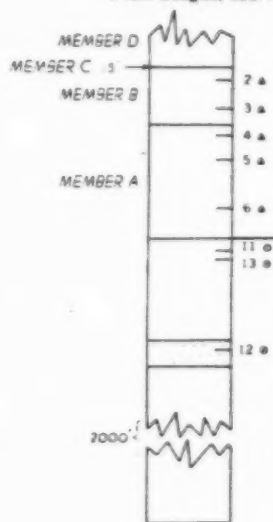
CASTLE RIVER
BETWEEN S.W. 1/4 OF S. 24
AND S.E. OF S. 24

CROWSNEST AND OLDMAN RIVERS
BETWEEN S. 29. AND S. 36.
T. 7, R. 1, W. 5
(Data from Douglas)

HIGHWOOD RIVER
BETWEEN LSD. 2, S. 10, AND
LSD. 10, S. 11, T. 18, R. 2, W. 5



OLDMAN RIVER
BETWEEN S. 12, T. 10, R. 2,
AND S. 5, T. 10, R. 1, W. 5
(From Douglas, 1950)



MEMBER E

MEMBER D

MEMBER C 15

MEMBER B

MEMBER A

MEMBER E

MEMBER D

MEMBER C 15

MEMBER B

Contact covered
MEMBER A

LEGEND

- Figures refer to fossil localities
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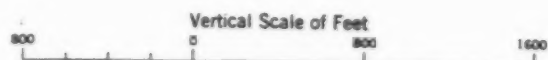


Figure 6 - Correlation of Upper Cretaceous - Tertiary strata in southern Alberta. From Tozer (1956, Fig. 2).

